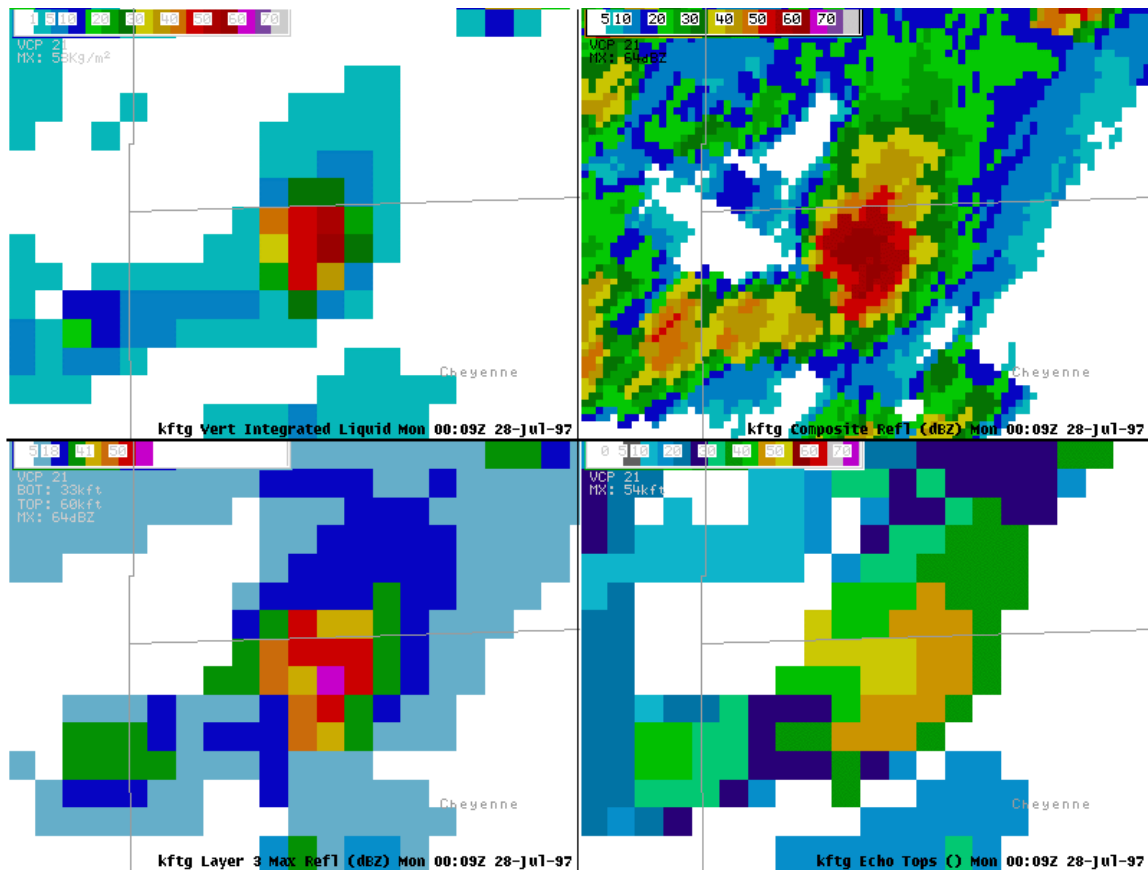


Distance Learning Operations Course



IC 5.5 WSR-88D Derived Products

Presented by

The Warning Decision Training Branch

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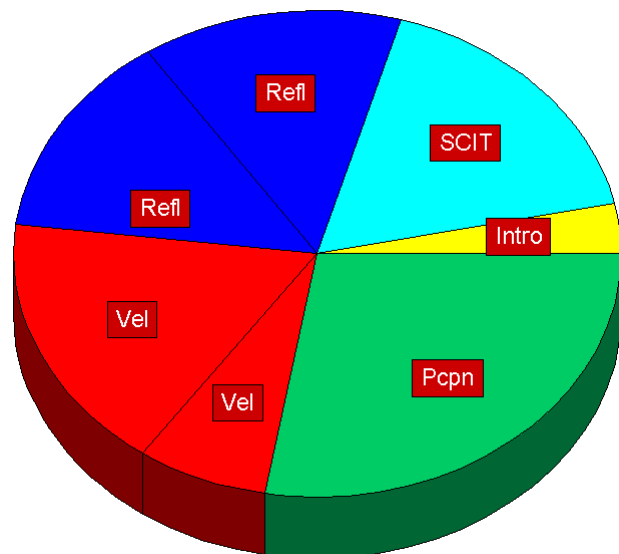
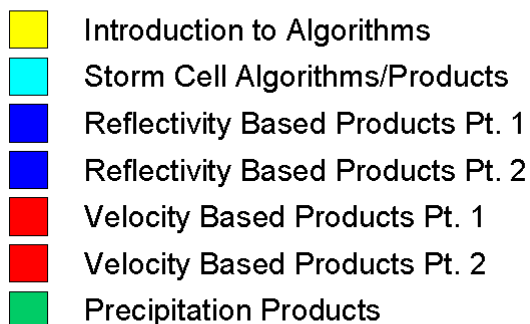
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Preface

Welcome to *WSR-88D Derived Products*! This Student Guide is to be used during the *WSR-88D Derived Products* teletraining session. You should place this in your DLOC student binder. This Student Guide not only contains materials presented in the teletraining presentations, but also practice exercises, and supplemental materials. To most effectively learn the material, it is strongly suggested that after attending teletraining, you do the worksheets and exercises in this Student Guide. When answering the questions, you may then choose to review this Student Guide.

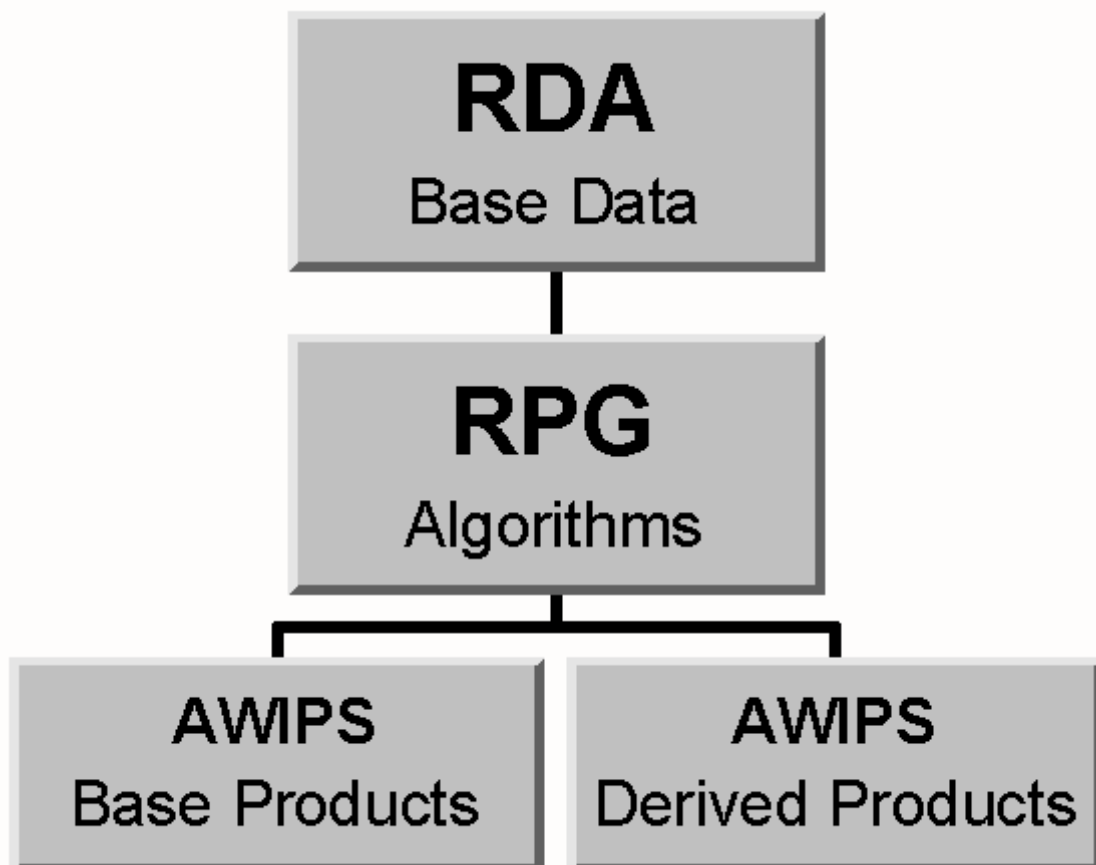
Before taking Exam 3, you should be comfortable with the objectives listed in each of the six lessons of this Student Guide as well as the answers to review exercises. Worksheets are also provided for those who want a little extra practice.

Overview



Objective

1. Interpret all derived products of the WSR-88D, including:
 - a. Specific characteristics of Derived Products,
 - b. Strengths and limitations of Derived Products,
 - c. Specific operational applications of Derived Products



IC 5.5 WSR-88D Derived Products

ELEVATION ANGLE PRODUCTS	Product ID #	Spatial Resolution		Number of Data Levels Available	MAX Range of Product (nm)	Product Coverage (Dimensions)		Load- shed Priority #	Saved on Archive Level 3 Modes:	NIDS Products		NAPUPS
		nm	X nm or deg			Radius (nm)	nm X nm					
Base Reflectivity (R)	16	0.54	1 deg.	8	124	124		56				
	17	1.1	1 deg.	8	248	248		55				
	18	2.2	1 deg.	8	248	248		54				
	19	0.54	1 deg.	16	124	124		89	Y"	Y*	Y*	Y*
	20	1.1	1 deg.	16	248	248		88	Y"	Y"	Y"	Y"
Mean Radial Velocity (V)	21	2.2	1 deg.	16	248	248		87				
	22	0.13	1 deg.	8	32	32		53				
	23	0.27	1 deg.	8	62	62		52				
	24	0.54	1 deg.	8	124	124		51				
	25	0.13	1 deg.	16	32	32		86	Y"	Y"	Y"	Y"
Spectrum Width (SW)	26	0.27	1 deg.	16	62	62		85				
	27	0.54	1 deg.	16	124	124		84	Y"	Y*	Y*	Y*
	28	0.13	1 deg.	8	32	32		60	Y"	Y"	Y"	Y"
	29	0.27	1 deg.	8	62	62		59				
	30	0.54	1 deg.	8	124	124		58	Y"	Y"	Y"	Y"
User Selectable Precip (USP)	31	1.1	1 deg.	16	124	124		57				
	32	0.54	1 deg.	256	124	124		57				
	33	0.54	1 deg.	16	124	124		57				
	34	0.54	1.4 deg.	8	124	124		99	Y	Y	Y	Y
	35	0.54	0.54	8	124	124		48				
Composite Reflectivity (CR)	36	2.2	2.2	8	248	248		47	Y3	Y	Y	Y
	37	0.54	0.54	16	124	124		76				
	38	2.2	2.2	16	248	248		75	Y3	Y	Y	Y
	39	0.54	0.54	16	124	124		44				
	40	2.2	2.2	16	248	248		43				
Composite Reflectivity Contour (CRC)	41	2.2	2.2	16	124	124		66	Y3	Y	Y	Y
	42	2.2	2.2	16	124	124		45				

" = Lowest Tilt ; ~ = Lowest 2 Tilts ; ^ = Lowest 3 Tilts ; * = Lowest 4 tilts
3 = Every Third Volume Scans ; 6 = Every Sixth Volume Scans

ELEVATION ANGLE PRODUCTS		Product ID #	Spatial Resolution		Number of Data Levels Available	MAX Range of Product (nm)	Product Coverage (Dimensions)		Load-shed Priority #	Saved on Archive Level 3	NIDS Products			NAPUPS		
			nm	X nm or deg			Radius (nm)	nm X nm			Modes:			Modes:		
											A	B	C	A	B	C
Severe Weather Analysis (SWA) <i>(SWR) Reflectivity</i> <i>(SWV) Velocity</i> <i>(SWW) Spectrum Width</i> <i>(SWS) Radial Shear</i>		43	0.54	1 deg.	16	124	---	27 x 27	94	---	---	---	---	---	---	---
		44	0.13	1 deg.	16	124	---	27 x 27	93	---	---	---	---	---	---	---
		45	0.13	1 deg.	8	124	---	27 x 27	92	---	---	---	---	---	---	---
		46	0.27	1 deg.	16	124	---	27 x 27	46	---	---	---	---	---	---	---
Severe Weather Probability (SWP)		47	15.4	15.4	N/A	124	124	-----	69	Y	---	---	---	Y	---	---
		48	N/A	N/A	5	124	---	-----	82	Y6	Y	Y	Y	Y	Y	Y
Velocity Azimuth Display Profile (VWP)		49	0.54	1 deg.	8	124	---	13.5 x 13.5	96	---	---	---	---	---	---	---
			0.27	1 deg.	N/A	124	---	13.5 x 13.5	96	---	---	---	---	---	---	---
			0.27	1 deg.	N/A	124	---	13.5 x 13.5	96	---	---	---	---	---	---	---
Combined Moment (CM) <i>Reflectivity</i> <i>Velocity</i> <i>Spectrum Width</i>		50	0.54	0.27vertical	16	124	---	-----	98	---	---	---	---	---	---	---
		51	0.54	0.27vertical	16	124	---	-----	97	---	---	---	---	---	---	---
		52	0.54	0.27vertical	8	124	---	-----	95	---	---	---	---	---	---	---
		53	0.54	0.54	8	124	---	27 x 27	---	---	---	---	---	---	---	---
Storm-Relative Mean Radial Velocity Region (SRR)		55	0.27	1 deg.	16	124	---	27 x 27	67	---	---	---	---	---	---	---
		56	0.54	1 deg.	16	124	124	-----	68	Y"	---	---	---	Y~	---	---
Storm-Relative Mean Radial Velocity Map (SRM)		57	2.2	2.2	16	124	124	-----	83	Y	---	---	---	Y	---	---
			N/A	N/A	N/A	248	248	-----	74	Y	---	---	---	Y	---	---
			N/A	N/A	5	124	124	-----	72	Y	---	---	---	Y	---	---
Vertically Integrated Liquid (VIL)		58	N/A	N/A	N/A	248	248	-----	74	Y	---	---	---	Y	---	---
Storm Tracking Information (STI)		59	N/A	N/A	5	124	124	-----	72	Y	---	---	---	Y	---	---
Hail Index (HI)																

" = Lowest Tilt ; ~ = Lowest 2 Tilts ; ^ = Lowest 3 Tilts ; * = Lowest 4 tilts

3 = Every Third Volume Scans ; 6 = Every Sixth Volume Scans

IC 5.5 WSR-88D Derived Products

ELEVATION ANGLE PRODUCTS	Product ID #	Spatial Resolution		Number of Data Levels Available	MAX Range of Product (nm)	Product Coverage		Load- shed Priority #	Saved on Archive Level 3		NIDS Products		NAPUPS	
		nm	X nm or deg			Radius (nm)	nm X nm		Modes:		Modes:		Modes:	
									A	B	A	B	A	B
Mesocyclone (M)	60	N/A	N/A	3	124	124		71	Y			Y		
Tornado Vortex Signature (TVS)	61	N/A	N/A	2	124	124		70	Y			Y		
Storm Structure (SS)	62	N/A	N/A	N/A	248	248		73	Y3			Y		
Layer Composite Reflectivity Average (LRA)	63,64,89	2.2	2.2	8	124 - 175		248 x 248	42,42,10						
Layer Composite Reflectivity Maximum (LRM)	65,66,90	2.2	2.2	8	124 - 175		248 x 248	63,62,61			Y		Y	
LRM AP Removed (APR)	67	2.2	2.2	8	124 - 175		248 x 248	62			Y	Y		
Use Alert Message (UAM)	73	N/A	N/A	N/A	N/A	N/A		91						
Radar Coded Message (RCM)	74	Approx 5 (1/16 LFM)	Approx 5 (1/16 LFM)	9	248	248		65	Y				Y	
Free Text Message (FTM)	75	N/A	N/A	N/A	N/A	N/A		91						
One Hour Precipitation (OHP)	78	1.1	1 deg.	16	124	124		81	Y3		Y	Y	Y	
Three Hour Precipitation (THP)	79	1.1	1 deg.	16	124	124		77			Y	Y	Y	
Storm Total Precipitation (STP)	80	1.1	1 deg.	16	124	124		78	Y3		Y	Y	Y	
Digital Precipitation Array (DPA)	81	Approx 5 (1/40 LFM)	Approx 5 (1/40 LFM)	256	124	124		80	Y	Y	Y	Y	Y	
Supplemental Precipitation Data (SPD)	82	N/A	N/A	N/A	124			79	Y			Y	Y	
Velocity Azimuth Display (VAD)	84	N/A	N/A	8	0.54 - 124			57						
Reflectivity Cross Section (RCS)	85	0.54	0.27vertical	8	124			50						
Velocity Cross Section (VCS)	86	0.54	0.27vertical	8	124			49						
Combined Shear(CS)	87	0.27 to 2.2	1 deg.	16	124		124 x 124	39						
Combined Shear Contour (CSC)	88	0.27 to 2.2	1 deg.	8	124		124 x 124	38						

" = Lowest Tilt ; ~ = Lowest 2 Tilts ; ^ = Lowest 3 Tilts ; * = Lowest 4 tilts
3 = Every Third Volume Scans ; 6 = Every Sixth Volume Scans

Lesson 1: Introduction to Meteorological Algorithms

An algorithm is a recursive mathematical procedure, the computers stock and trade. Numerous meteorological algorithms are used in the computer programs that reside at the RPG. The products output by these programs are called Derived Products.

The purpose of the meteorological algorithms is to produce products that will assist the user in rapidly analyzing the data for significant weather events. It is important to note that the Derived Products are only as good as the algorithms that produce them. Decisions should never be based solely on Derived Products. The Derived Products should be used like other types of computer guidance (i.e., MOS).

The meteorological algorithms used by the WSR-88D vary considerably in their complexity. The numerical manipulations in some algorithms are very complex, and some are simple. Many algorithms become more complex as certain criteria are met.

Algorithms also differ in their maturity. The maturity of an algorithm depends on the amount of research incorporated, the quality of the programming, the ease of interpretation of the product produced by the algorithm, and the applicability of that product from site to site. Some of the current algorithms work fine in their present form. At this time, some algorithms are immature. The algorithms that need work will be improved over the next few years by the Radar Operations Center (ROC). So, products that are not that useful now, may be better in the future. Do not let the immaturity of an algorithm affect how you feel about the WSR-88D.

WSR-88D Meteorological Algorithm

Purpose of Derived Products

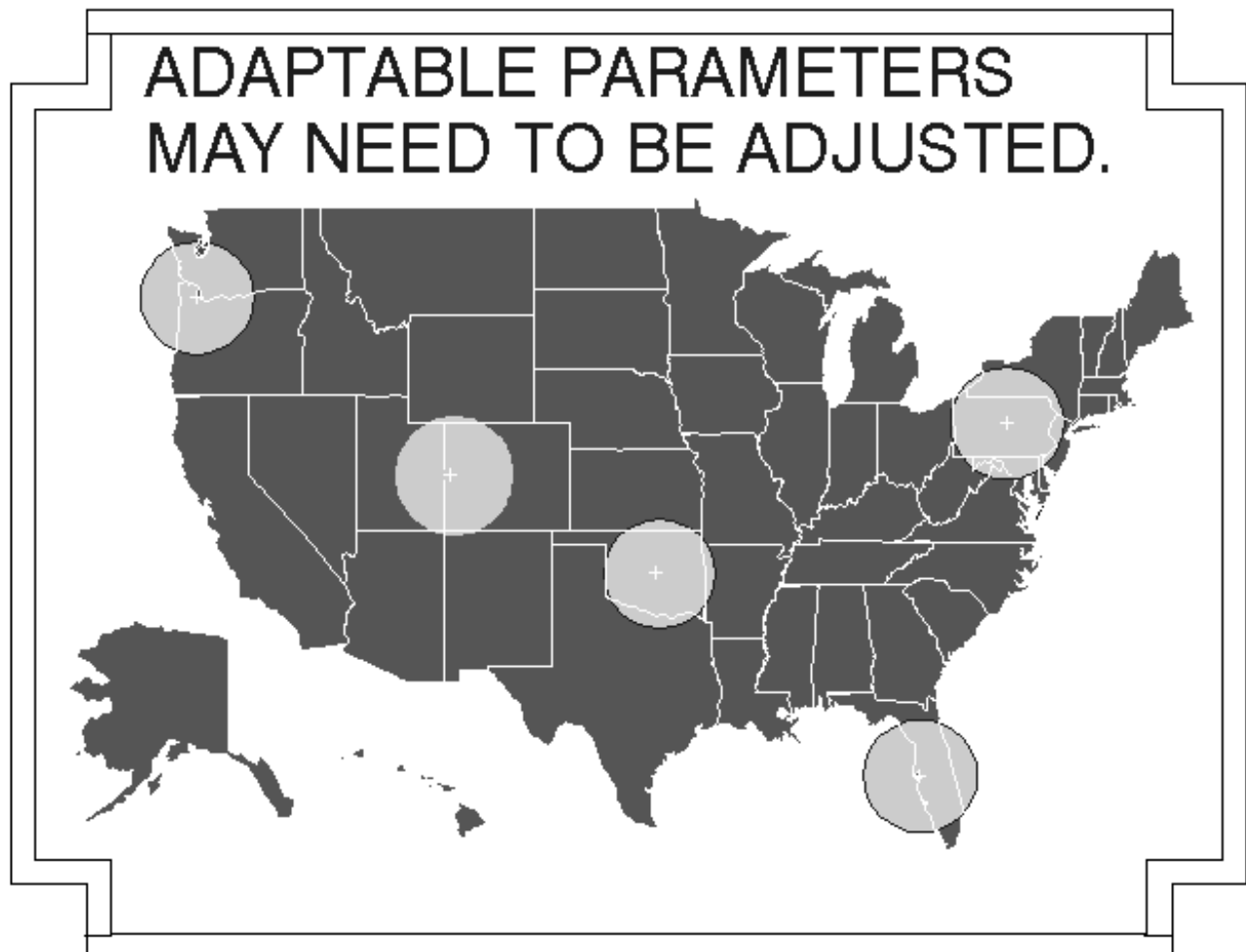
Algorithms complexities vary

Maturity of an Algorithm

Adaptable Parameters

It has long been recognized that in different climatological regimes, adjustments may need to be made to the meteorological algorithms. The values (parameters) within an algorithm that can be changed are called the Adaptable Parameters.

There are over 200 meteorological adaptable parameters in the WSR-88D. Since changing an adaptable parameter may have unexpected results on algorithm output, and affect other algorithms, most meteorological adaptable parameters are ROC controlled, meaning that you do not have the authority to change a number without ROC approval. Almost all of the meteorological adaptable parameters that can be changed at the ORPG HCI are password protected.



IC 5.5 WSR-88D Derived Products

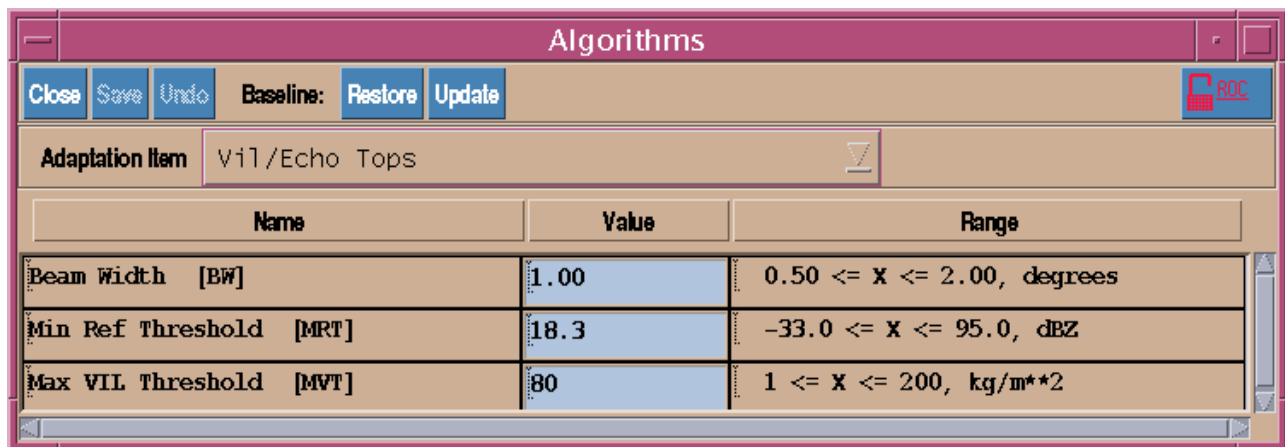


Figure 1-1. Here is an example of adaptable parameters within the VIL algorithm (ORPG HCI).

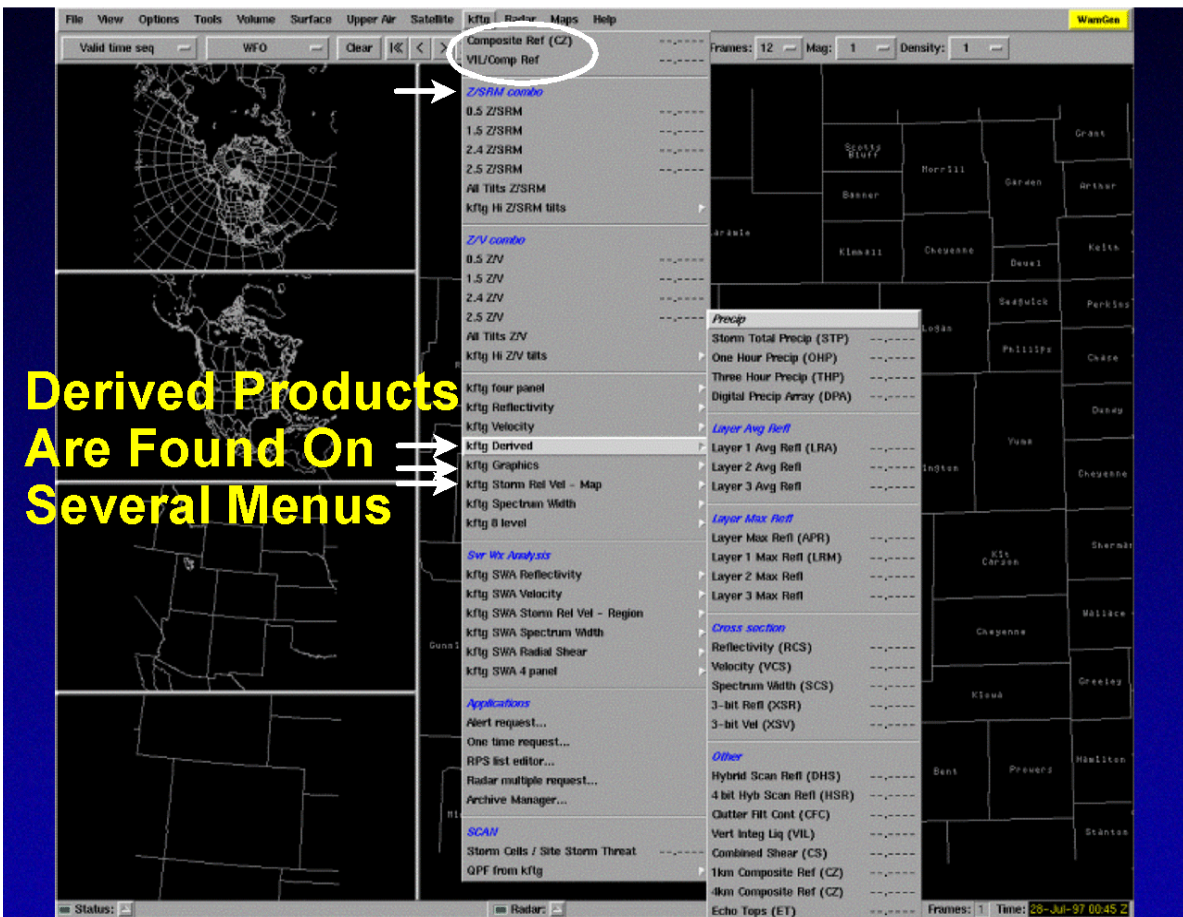


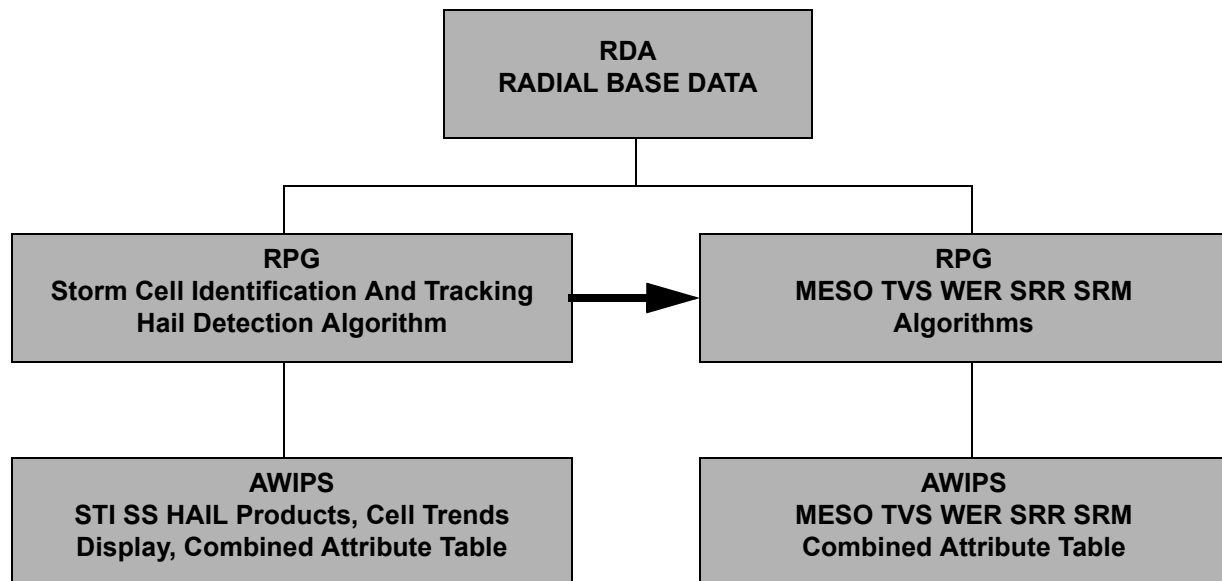
Figure 1-2. Derived products are found on several menus on the AWIPS Workstation.

Lesson 2: Storm Cell Algorithms and Products

This lesson describes how the Storm Cell Identification and Tracking (SCIT) algorithm identifies, tracks and forecast the movement of storm cells. Certain attributes of the identified cells are then utilized by the Hail Detection Algorithm (HDA) to calculate probabilities of hail and severe hail, and to estimate maximum hail size. Descriptions, and a listing of limitations and strengths are included for the following:

1. **Storm Track Information** (STI - product #58),
2. **Storm Structure** (SS - product #62),
3. **Hail Index** (HI - product #59), and
4. **Cell Trends Display Function**.

Overview



Objective

Without references and according to the lesson, you will be able to identify one strength and one limitation of the:

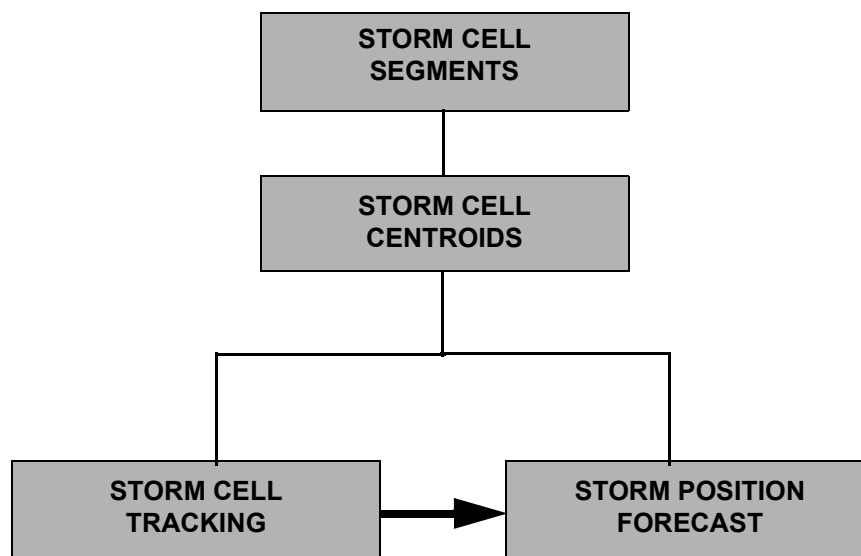
1. Storm Tracking Information (STI) product,
2. Hail Index Product (HI), and
3. Cell Trends display.

Storm Cell Identification And Tracking

Introduction

The Storm Cell Identification and Tracking (SCIT) algorithm was included with the WSR-88D software as one of the major enhancements of Build 9.0. The objective of the algorithm is to identify, track, and forecast the movement of storm cells. The primary graphic product produced by this algorithm is Storm Track Information (STI - Product ID # 58).

Data developed by this algorithm are used extensively as input to several other products (i.e., HI, SS, SRM, SRR, WER, M, TVS, RCM, CR Combined Attribute Table) and the Cell Trends display.



The SCIT algorithm consists of four subfunctions: Storm Cell Segments, Storm Cell Centroids, Storm Cell Tracking, and Storm Position Forecast. The **Storm Cell Segments** subfunction identifies the radial sequences of reflectivity (segments), and outputs information on these segments to the **Storm Cell Centroids** subfunction. The **Storm Cell Centroids** subfunction groups the segments into two-dimensional components, vertically correlates these components into three-dimensional cells, and calculates these cells' attributes. The cells and their attributes are output to Storm Cell Tracking and Storm Position Forecast. **Storm Cell Tracking** monitors the movement of the cells by matching cells found in the current volume scan to the cells from the previous volume scan. **Storm Position Forecast** predicts future centroid locations based on a history of the cell's movement.

SCIT Algorithm Overview

Storm Cell Segments

Segment - a run of contiguous range bins along a radial with reflectivity values greater than or equal to a specified threshold.

Definition

The Storm Cell Segments subfunction searches for segments of up to seven different **minimum reflectivity thresholds**. The segment must have a length greater than a **minimum segment length**, and may contain a specified **dropout number** of contiguous range bins that are within the **dropout reflectivity difference** below the minimum reflectivity threshold. The default values of the adaptable parameters are:

Process

- Minimum Reflectivity Thresholds = 30, 35, 40, 45, 50, 55, 60, dBZ
- Minimum Segment Length = 1.9 km (1.1 nm or two range bins),

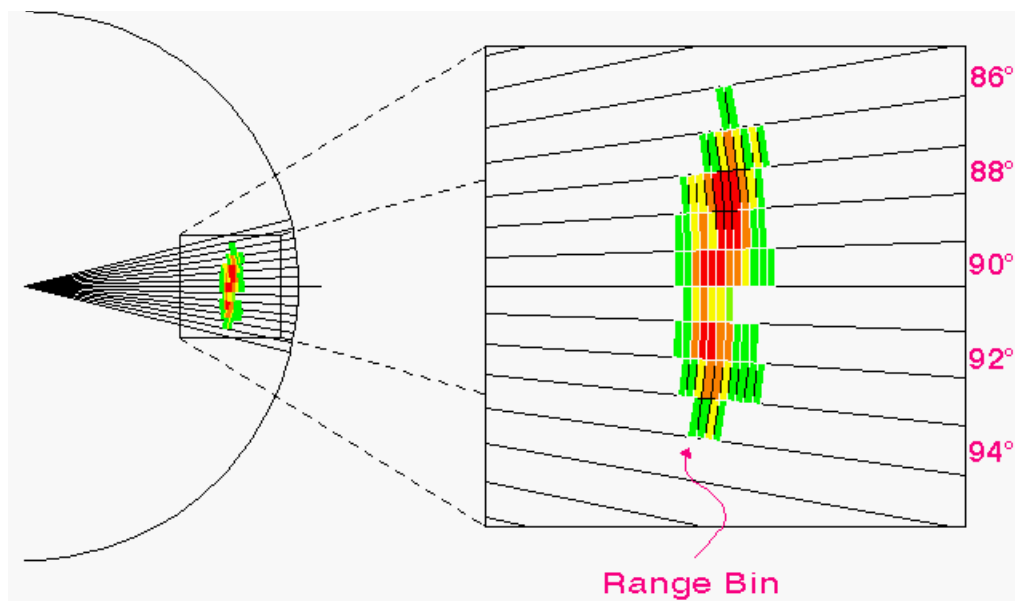


Figure 2-1. Looking closer at the radials, you can see how the reflectivity information is quantified. The basic measurements of reflectivity are made in $1^\circ \times .54\text{nm}$ **range bin**. The function of this algorithm is to combine the individual range bin into storm segments along the radial. Note the segments in the figure.

- Dropout Reflectivity Difference = 5 dBZ, and
- Dropout Number = 2.

The *Storm Cell Segments* subfunction searches for segments on each radial as the data arrives at the RPG. First, a search is done for segments using the lowest minimum reflectivity (default is 30 dBZ). All other range bins are discarded from further processing. Then a search is made of the detected (30 dBZ) segments for segments of the next minimum reflectivity threshold (35 dBZ). Then a search of those (35 dBZ) segments is made for segments of the next threshold (40 dBZ), and so on through the seventh threshold (60 dBZ).

A portion of a radial is depicted in the graphic on the next page and annotated with the reflectivity values of each ($1^\circ \times 0.54\text{ nm}$) range bin. Given the default values of the adaptable parameters, seven segments would be defined.

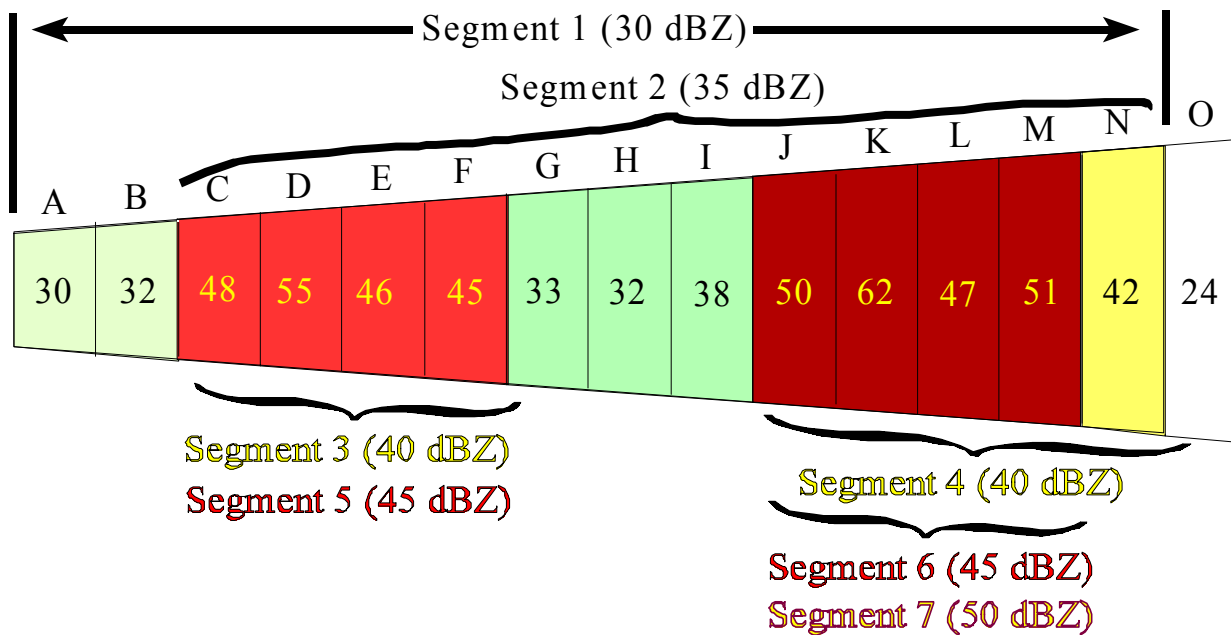


Figure 2-2. In the initial search for a 30 dBZ segment (labeled Segment 1), only the range bin labeled “O” would be eliminated. Segment 2 (“C” through “N”) would be selected in the search for 35 dBZ segments (range bins “G” and “H” would remain since up to two contiguous range bins within 5 dBZ of the minimum reflectivity threshold can be contained in the segment). The 40 dBZ segments would include Segment 3 (“C through F”) and Segment 4 (“J through N”). Segments 5 and 6 would be defined as 45 dBZ segments, and Segment 7 would be further defined as a 50 dBZ segment. Note that range bin “D” (55 dBZ) and range bin “K” (62 dBZ) would not be considered separate segments since they do not exceed the minimum segment length.

As can be seen from the example, numerous segments could be identified along a single radial. To reduce the processing task, the number of segments of a given threshold is limited to 15 (adaptable parameter) per radial. In other words, there is a potential for up to 105 segments on a single radial (7 thresholds X 15 segments per threshold). Investigations have shown that these thresholds will only be exceeded in very active weather situations.

Component - A two-dimensional area of combined segments on a single elevation slice.

Centroid - A three dimensional location of a cell's center of mass.

Storm Cell Centroids

Definitions

Process | At each elevation slice, the Storm Cell Centroids subfunction groups adjacent segments of each reflectivity threshold into two-dimensional components. If components overlap, the component with the higher reflectivity is saved and the other(s) discarded. **Only the smaller “bull’s eyes” of high reflectivity are saved for correlation into three-dimensional cells.** Therefore, cells are defined by their areas of highest reflectivity.

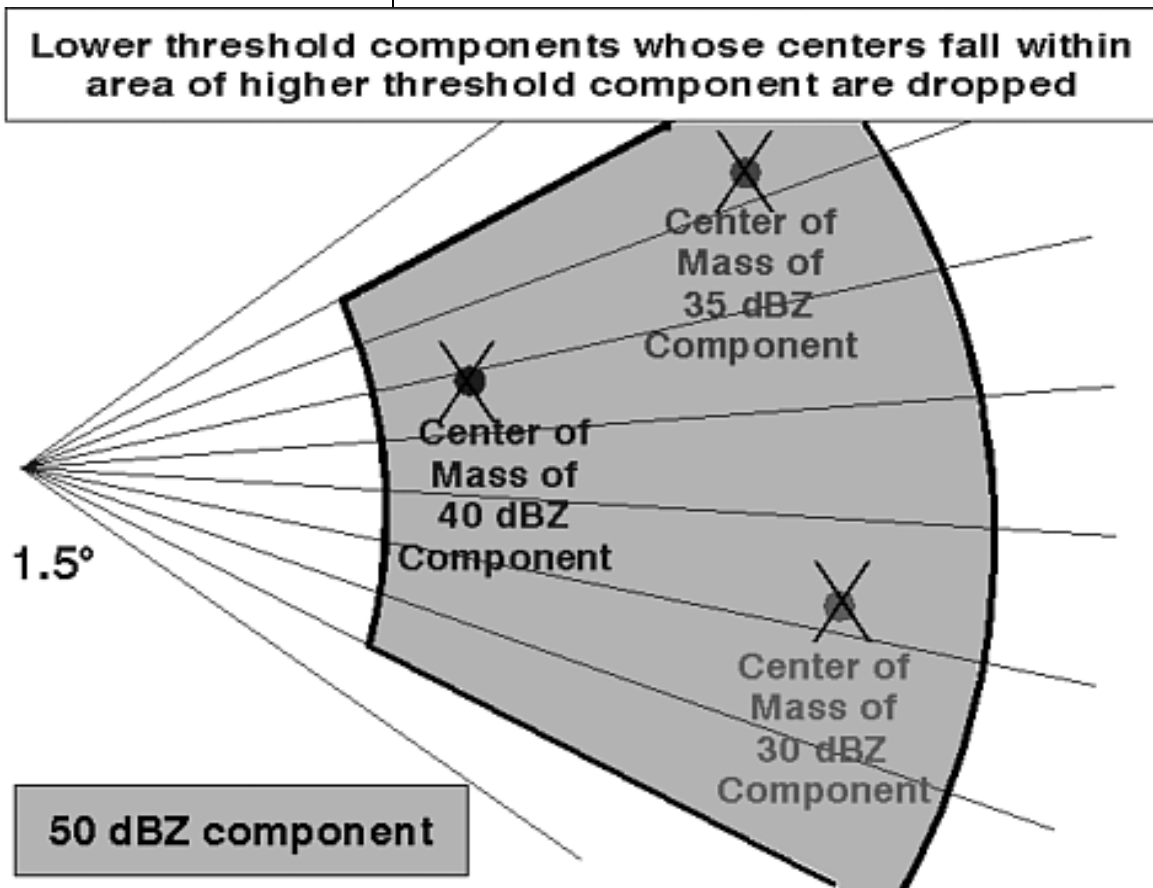


Figure 2-3. Storm Cell Centroid Processing

The components are vertically correlated by comparing the proximity of the centers of every component with those in adjacent elevation scans. Components with the largest masses are compared first. If at least two components are vertically correlated, a cell is created.

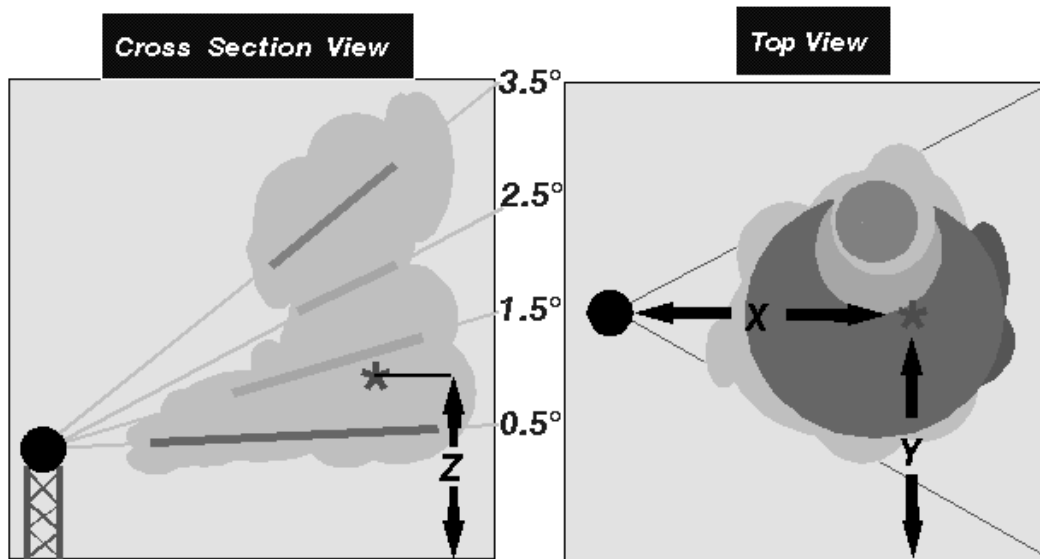


Figure 2-4. Centroid Locations

For each identified cell the following attributes are calculated:

- centroid (in polar coordinates),
- height of the centroid (ARL - Above Radar Level),
- maximum (3-bin averaged) reflectivity,
- height of the maximum reflectivity (beam centerpoint height - ARL),
- cell base and top (ARL),
- number of components, and
- Cell-based Vertically Integrated Liquid (VIL).

A calculation of VIL is made for each cell identified by Storm Cell Centroids by vertically integrating maximum reflectivity values of a cell's correlated components. This is a **different** calculation than the gridded VIL product (VIL - Product ID #57). As can be shown on the following example, a fast-moving or highly tilted storm will usually have a higher Cell-based VIL than Grid-based VIL.

Storm Cell Centroids Output

Cell-based VIL

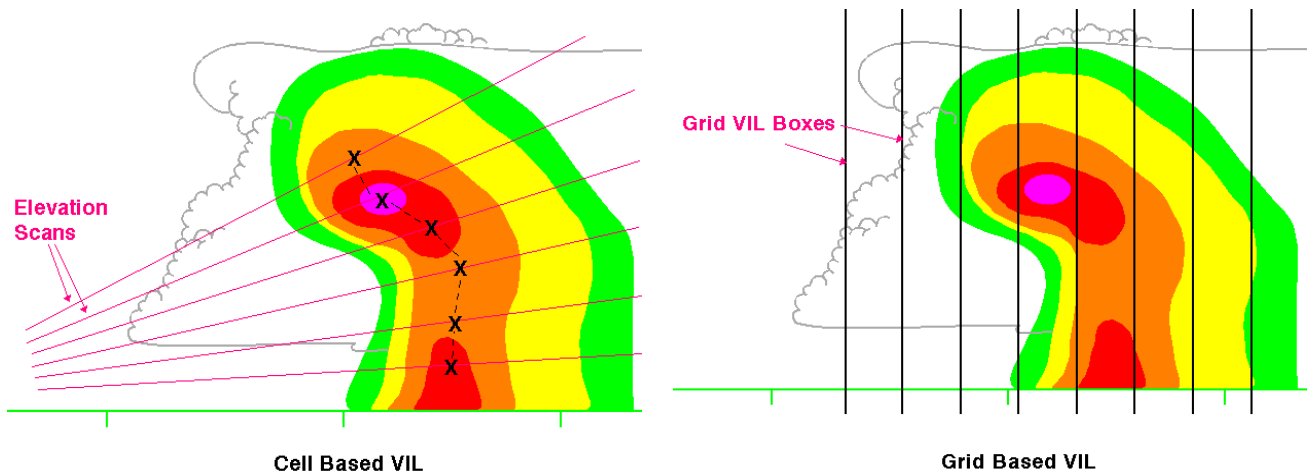


Figure 2-5. Cell-based vs. Grid-based VIL.

Storm Cell Tracking

Process Storm Cell Tracking monitors the movement of storm cells by matching cells found in the current volume scan to the cells from the previous volume scan. Starting with the cell with the highest Cell-based VIL, a comparison is done of its centroid location with the projected (based on past movement) centroids from the previous volume scan. The closest projected centroid within a threshold distance (speed limitation) is considered the same cell.

If a correlation is made, the cell is given the same ID as in the previous volume scan. If no correlation is made, the cell is given a new ID. The ID assigned to a Cell consists of a letter-number combination (A0, B0, C0 ... Z0, A1, B1... Z1, A2, B2 ... Z9). This adds some value to the ID, such as cell

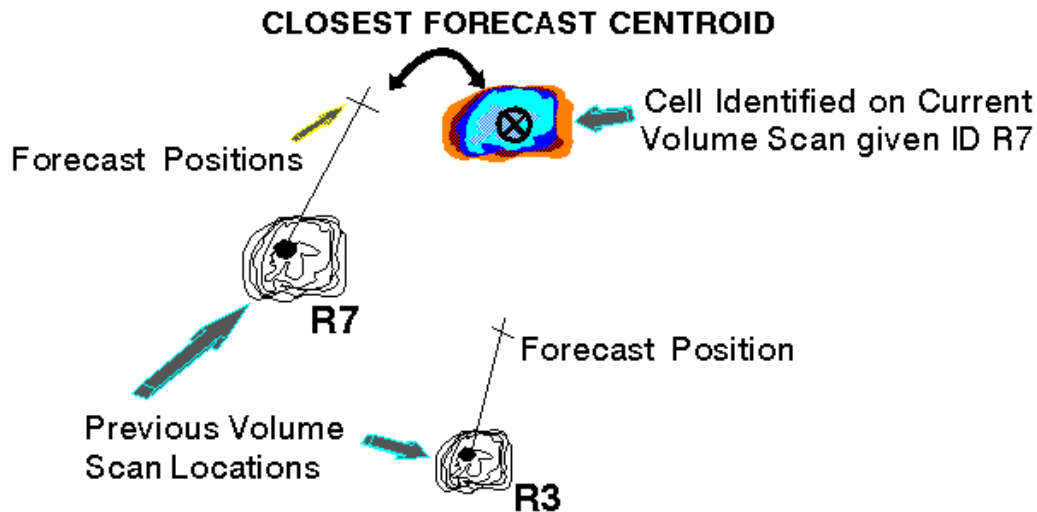


Figure 2-6. Storm Tracking Process. Centroid location is compared with forecast location of centroids from the previous volume scan.

R7 has been identified longer than cell H8 (**the number has precedence over the letter in this scheme**). The list of IDs will reset to begin with A0 when the RPG is rebooted, or when a threshold time interval has lapsed without cells.

Storm Position Forecast

Process

Storm Position Forecast predicts the future centroid locations of cells based on a history of the cell's movement. The first time a cell is detected it is labeled a new cell, and the forecast movement used by the algorithm for processing purposes is either:

- a) the average movement of all identified cells, or
- b) if no other cells are identified, the default speed and direction as set at the ORPG HCI.

Subsequently, each time the cell is detected, a prediction is made using a linear least squares extrapolation of the cell's previous movement. A comparison of the current centroid location is

Storm Track Information Graphic Product

Product Description

made to the previous forecast position, with the duration of the forecast (0, 15, 30, 45, or 60 minutes) dependent on the magnitude of this departure. In other words, the larger the error in the past volume scan forecast, the shorter (in time) the forecast.

Data developed by the SCIT algorithm is directly input to the Storm Track Information Product (STI - Product ID #58). The STI product can display up to 100 cells identified by the SCIT algorithm on a single product. It is also possible to display the actual past positions of the centroid on up to 13 (default 10) previous volume scans. Cells with a movement of less than a minimum speed (default 5 kts) are circled to indicate little movement, and past positions and forecast tracks are not displayed. The following symbols are displayed on the product:

⊗ centroid location,

• past position (volume scan increments with a line between each symbol), and

+ forecast position (15 minute increments with a straight line connecting all forecast positions),

⊗ stationary (<5 kts).

STI Product Parameters

See Figure 2-7 for an example of the STI product.

STI product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Storm Track Info
- PAGE #: This is the page number of the attribute table.
- DATE: Day of week, time, and date in UTC

STI product annotations:

- STI Attribute Table

Additional STI Product Characteristics

- RANGE: 248 nm

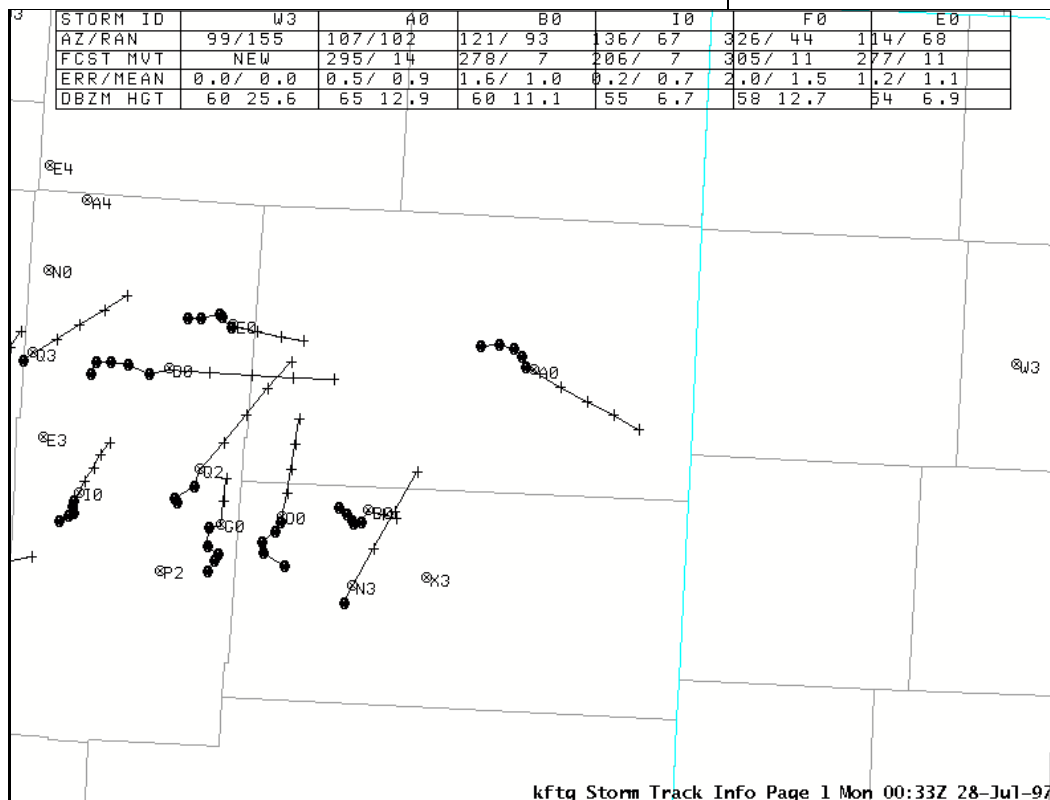


Figure 2-7. Storm Track Information (STI) Product.

The STI Attribute Table appears at the top of the STI product, and contains information on all identified cells. The STI Attribute Table lists the cells in

STI Attribute Table

order of Cell-based VIL from left to right from page 1 to the last page. On the first volume scan a cell is identified, the word “NEW” is placed on the line for forecast movement.

STORM/ID	W3	A0	B0	I0	F0	E0
AZ/RAN	99/155	107/102	121/ 93	136/ 67	326/ 44	114/ 68
FCST/MVT	NEW	295/ 14	278/ 7	206/ 7	305/ 11	277/ 11
ERR/MEAN	0.0/ 0.0	0.5/ 0.9	1.6/ 1.0	0.2/ 0.7	2.0/ 1.5	1.2/ 1.1
DBZM HGT	60 25.6	65 12.9	60 11.1	55 6.7	58 12.7	54 6.9

Figure 2-8. STI Attribute Table which appears at the top of the STI product.

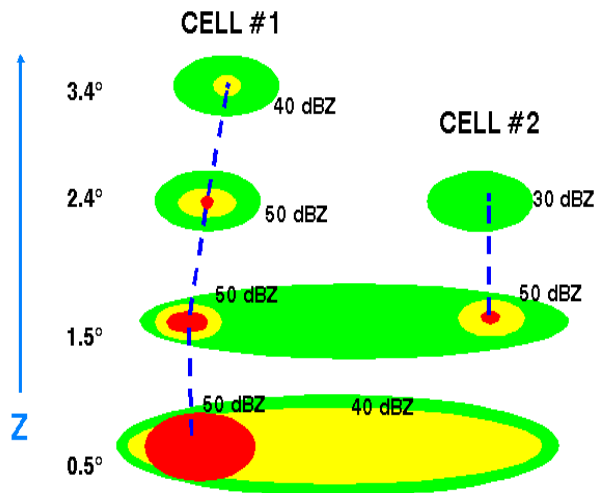
Storm Track Information Alphanumeric Product

If 100 cells were identified, with only six cells per page, there would be 17 pages of attributes, although only 6 pages are currently viewable in AWIPS.

An STI Alphanumeric Product is received and stored in a text file along with every STI Graphic Product. The name of the text file is in the form: **WSRSTIxxx**, where xxx is the radar ID. The STI Alphanumeric Product is displayable at the AWIPS text workstation, and contains information on the position and forecast of identified cells. The average speed and direction of all identified cells are shown near the top of the product. Cells are listed in order of Cell-based VIL. The azimuth and range of the current cell centroids along with the movement and forecast positions at 15, 30, 45, 60 minutes are listed.

Limitations

1. Errors may occur in the identification of cells and the calculation of cell attributes when cells are in close proximity. Recall from the previous discussion of Storm Cell Centroids that storm cells are defined by areas of highest reflectivity.



No component for cell #2 at 0.5°

Figure 2-9. Storm Cell Centroids that storm cells are defined by areas of highest reflectivity.

In Figure 2-9, a particularly high area of reflectivity (50 dBZ) occurred in Cell #1 at 0.5°, and only this area was saved as a component. Cell #2 has been identified with a Cell Base defined at the 1.5° slice even though a 40 dBZ echo exists at the 0.5° slice.

This type of problem will also affect other calculations such as Cell Top, Maximum Reflectivity Height, and Cell-based VIL. The operator should be skeptical of cell attributes anytime cells are in close proximity to each other.

Cell attributes of supercells may also be inconsistent the number of identified cells in a given storm may vary from volume scan to volume scan. An example of this problem is seen on Figure 2-10, where cell-based VIL is compared to gridded VIL for a large supercell storm.

2. Large errors may occur in the attributes of cells close to the RDA, especially in VCP 21. Recall that there are large gaps between elevation

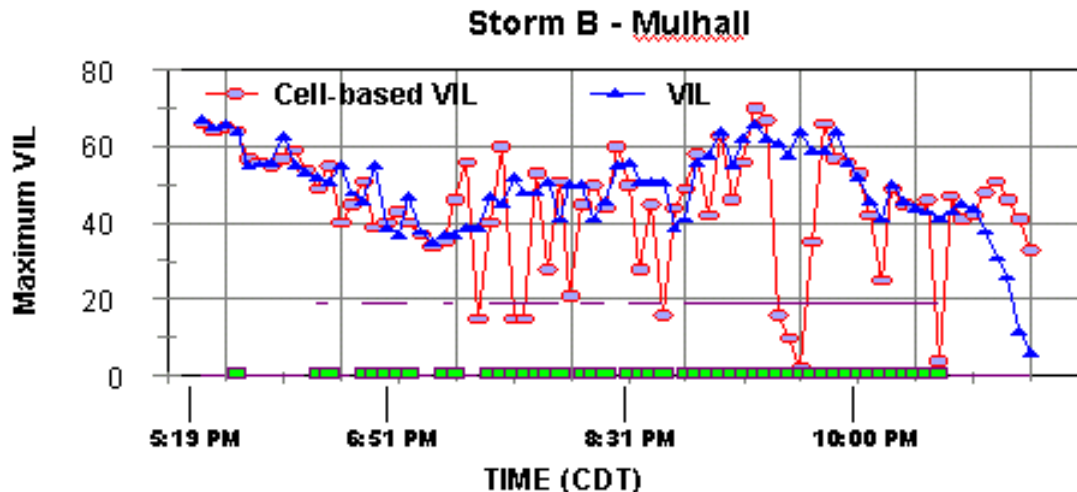


Figure 2-10. Comparison of cell-based VIL and gridded VIL for the “Mulhall” Storm that produced a long track tornado through the town of Mulhall, Oklahoma on May 3, 1999.

angles at higher slices in VCP 21. Calculations of Cell-based VIL, Cell Base, Cell Top, Height of Maximum Reflectivity, etc. can all be adversely affected by what the radar is **not** sampling in these gaps.

3. Unrepresentative movements are possible due to propagational effects. Due to development or dissipation, the high reflectivity cores change location within an identified cell from one volume scan to the next, resulting in false representation of the movement of the cell.

4. Forecast positions of curving cells are displayed as a straight line. Since position forecasts are always in a straight line, the past tracks of a cell should be taken into account when using the position forecast of a curving cell.

These limitations should also be considered anytime the operator uses the Cell Trends Display described in a later section.

1. *The product works best with well-defined widely separated cells.* Strengths/Applications

2. *A large number of past tracks, and/or four forecast positions signifies a more reliable cell movement.* Uneven spacing between past tracks, fewer than four forecast positions, and/or reidentification of cells indicate less reliable forecast positions.

3. *The STI product is useful as an overlay on volume products, but not limited to volume products.*

4. *Cell motion is used in Storm Relative Velocity products (SRM, SRR) covered in Lesson 4 (see page 71).*

5. *Cell attributes are critical inputs to the Hail Index product and Cell Trends Display.*

During active weather, the STI product could become extremely cluttered. Graphic controls are available at the AWIPS Workstations (Build 5.2.2 or later) to allow the operator to reduce the clutter on the STI product.

Icon Graphic Controls

The number of identified cells to be displayed (up to 100), and whether or not to display the past positions and/or forecast positions is independently selectable at each AWIPS Workstation. If 30 cells are identified by the SCIT algorithm, and an operator selects only 10 to be displayed, only the top 10 ranked by Cell-based VIL would be displayed on the STI graphic product. Information on all 30 cells are available on pages 1 through 5 of the STI Attribute Table and also on the paired STI

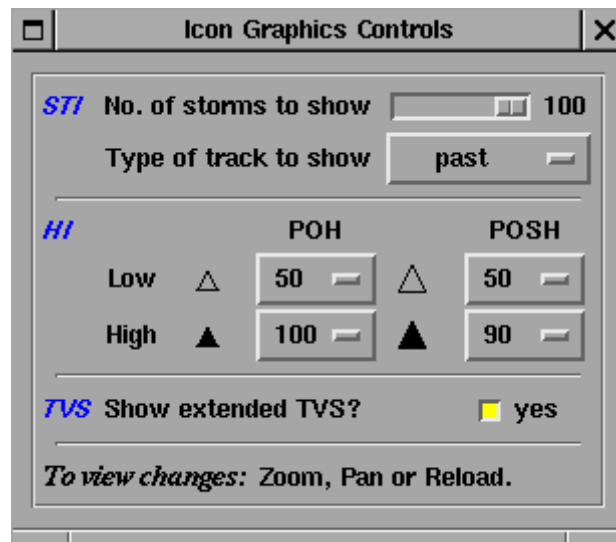


Figure 2-11. AWIPS Icon Graphics Control for STI, HDA, and TVS products.

alphanumeric product. All other AWIPS Workstations will not be effected by this setting.

Interim Summary

1. Errors occur in cell identification and tracking when cells are in close proximity.
2. Cell identification and tracking works best when storms are separated and little development of dissipation is occurring.
3. A large number of past tracks and/or four forecast positions are indications of reliable tracking.
4. Cell attributes are unreliable in VCP 21 within 60 nm of the RDA.

Storm Track Product

Storm Structure Alphanumeric Product

Introduction

Storm Structure (SS - Product ID # 62) is an alphanumeric product and can be displayed as a text product on the AWIPS Text Workstation (WSRSSTxxx). This product must be in the AWIPS data base for Cell Trends to be displayed.

STORM STRUCTURE						
RADAR ID	1	DATE/TIME	07:31:00/22:28:30	NUMBER OF STORM CELLS	1	
STORM ID	AZRAN	BASE	TOP	CELL BASED VIL	MAX REF	HEIGHT
	DEG/NM	KFT	KFT	KG/M**2	DBZ	KFT
S0	48/ 51	< 4.2	9.6	3	43	9.6

Figure 2-12. Storm Structure (SST) is an alphanumeric product only. This product must be in the AWIPS database to produce the Cell Trends Display.

Format

Data from one volume scan (start date/time listed) is displayed on the Storm Structure product. The number of storm cells detected is given on the second line of the product.

The Storm Structure alphanumeric product includes many of the cell attributes calculated by the SCIT algorithm:

Column 1: **STORM ID** (cells are ordered by Cell-based VIL),

Column 2: **AZRAN** (DEG/NM) (the azimuth and range to the centroid),

Column 3: **BASE** (KFT) (beam centerpoint height at the center of the lowest component detected, prefaced by "<" if on the lowest (0.5°) slice)

Column 4: **TOP** (KFT) (beam centerpoint height at the center of the uppermost component detected, prefaced by ">" if on the highest (19.5°) slice)

Column 5: **CELL BASED VIL** (KG/M**2)

Column 6: **MAX REF** (DBZ) (the maximum reflectivity found in the cell)

Column 7: **HEIGHT** (KFT) (beam centerpoint height at the center of the component containing the maximum reflectivity)

All of the data listed in the Storm Structure alphanumeric product is also available for each individual cell via Cell Trends graphic display. Some of the information (ID, AZRAN, MAX REF, HEIGHT) is available on the STI graphic product. Other attributes (ID, AZRAN, TOP, CELL BASED VIL, MAX REF, HEIGHT) are available in the Combined Attribute Table. Graphic displays of this information are preferred by most operators over the alphanumeric display.

Hail Detection Algorithm (HDA)

Introduction

The Hail Detection Algorithm (HDA) has been designed to look for high reflectivities above the freezing level. Input of the 0°C and -20°C altitudes at the ORPG HCI from a recent representative sounding can greatly improve algorithm output. The algorithm is designed to work independent of cell type, tilt, and overhang. The primary product produced by the algorithm is Hail Index (HI - Product ID #59) which can be useful in identifying cells that have the potential to produce hail.

The Hail Index product displays the following HDA estimates:

Probability Of Hail (POH) - identified as hail of any size, displayed in increments of 10%,

Probability Of Severe Hail (POSH) - identified as hail that is $\geq 3/4$ inch, displayed in increments of 10%, and

Maximum Expected Hail Size (MEHS) - the estimate of the largest hail size identified anywhere in the cell, computed in increments of 1/4 inch.

If the cell is beyond the hail processing range of 124 nm, then the hail estimates are labeled as UNKNOWN in the Attribute Table.

Process

The Hail Detection Algorithm searches for high values of reflectivity above the freezing level. The reflectivities used are the maximum reflectivities of cell components above the freezing level. For the calculation of the POH, the location of the highest reflectivity of at least 45 dBZ above the freezing level is found. The greater the height above the freezing level, the greater the POH. In the calculation of POSH and MEHS, reflectivities greater than 40 dBZ which exist above the freezing level are used. In addition, a weighting factor is used, such that the greater the reflectivity above 40 dBZ, and the higher the altitude at which this reflectivity exists, the greater the weighting factor used. Reflectivities greater than 50 dBZ, and higher than the altitude of the -20°C isotherm, carry the most weight. **This illustrates the need for users to update the altitude of the 0°C and -20°C levels regularly**, especially when significant change to

the atmosphere is experienced near the radar coverage area.

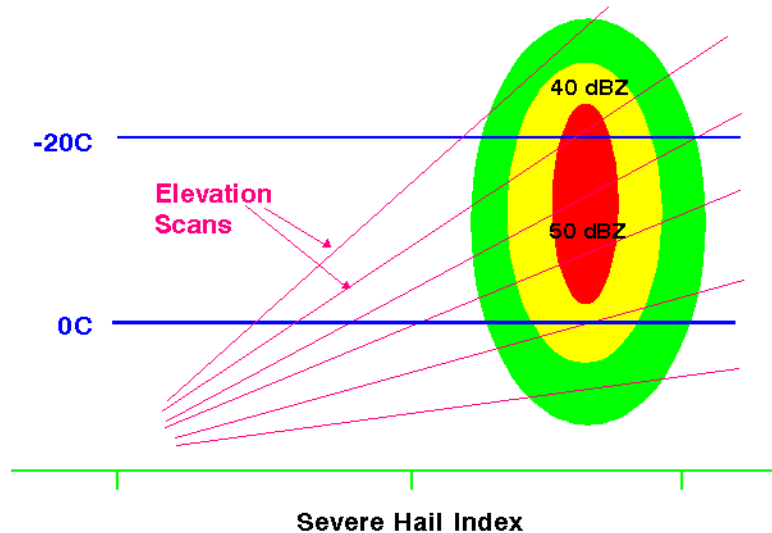


Figure 2-13. Hail Algorithm Process.

The Hail Index (HI - Product ID #59) graphic product uses symbols to depict the probability of hail. The POH will be represented with a small open or solid green triangle. For the triangle to appear the POH must exceed a **“Minimum Display Threshold”** (10% default). Whether the triangle is open or solid green depends on a **“Fill-in Threshold”** (50% default). The POSH is represented by a larger green triangle, again with the solid green triangle representing a “fill-in” threshold. The MEHS will be displayed in the center of the POSH symbol rounded to the nearest inch from 1 to 4. If a cell has hail identified that is less than 3/4 inch, then an asterisk (*) will be placed in the center of the POSH symbol.

Graphic controls are available at the AWIPS Workstations (Build 5.2.2 or later) to allow the operator to adjust the Minimum and Fill-In Thresholds for the Hail Index Icons. These changes will not be

Hail Index Product

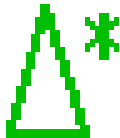
Icon Graphic Controls



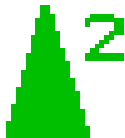
Minimum POH Display Threshold \leq POH $<$ Fill-in Threshold



POH \geq Fill-in Threshold & POSH $<$ Min. POSH Threshold



Minimum Display Threshold \leq POSH $<$ Fill-in Threshold



POSH \geq Fill-in Threshold

Figure 2-14. Hail Symbols

viewable until the product is zoomed or reloaded. Changes made here will not effect other AWIPS workstations.

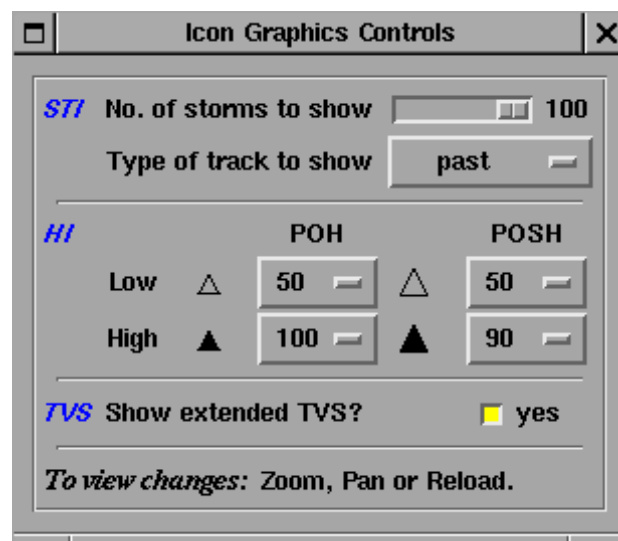


Figure 2-15. AWIPS Icon Graphics Control for STI, HDA, and TVS products.

The Hail Index Attribute Table will be available at the top of the product which lists the Cell ID, Azimuth and Range, POSH or POH, the MEHS (to the nearest 1/4 inch), and the last line in the table identifies the altitudes of the temperatures and the date/time at which the information was last updated, (1/1/96 12Z is displayed if data has not been entered). Each page of the table can contain up to 6 cells. Cells are ordered first by POSH and then by POH. In addition, the parameters of POSH, POH, and MEHS will be displayed in the Composite Reflectivity Combined Attribute Table and the Hail Index alphanumeric product.

Hail Index Attribute Table

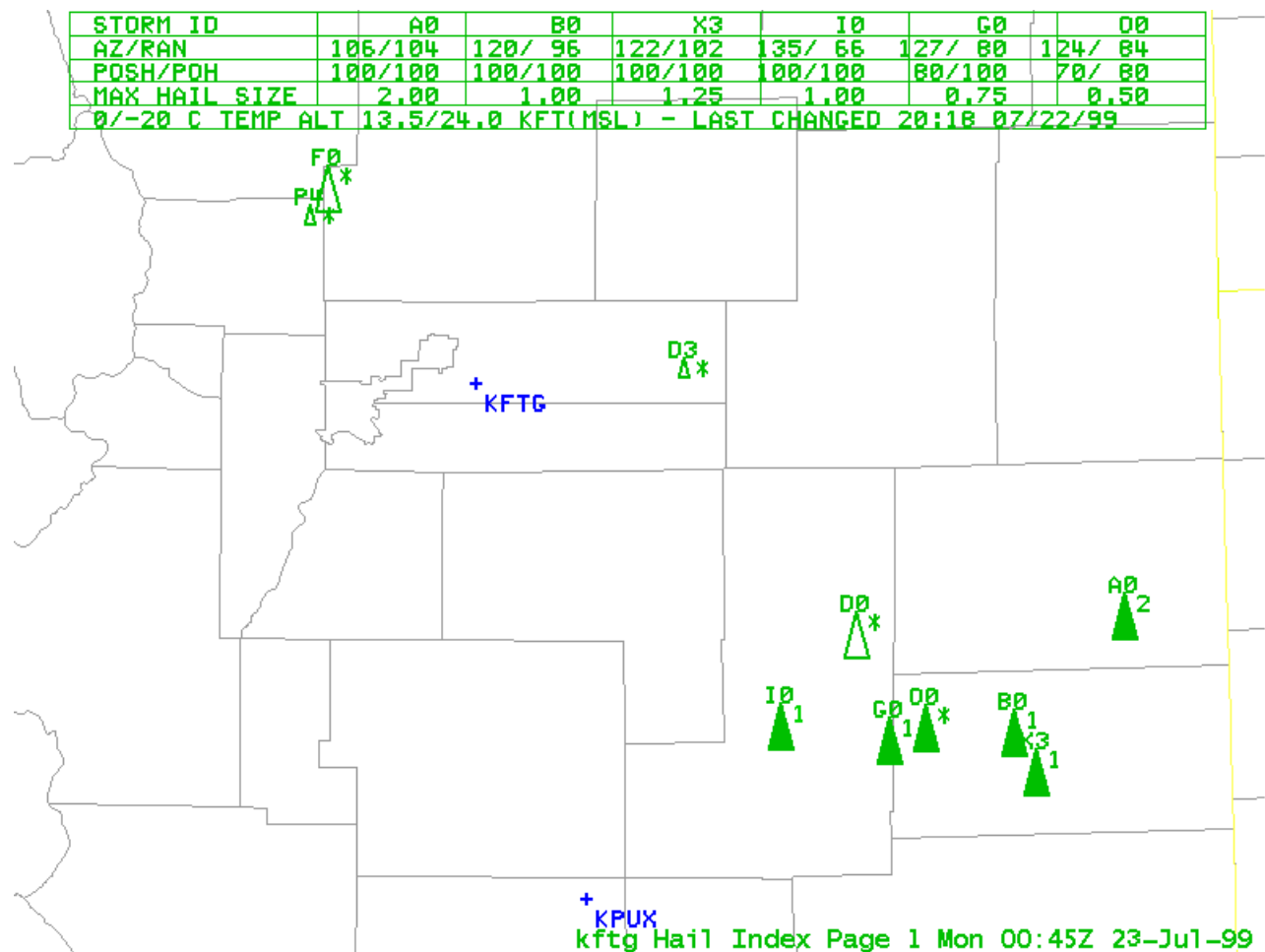


Figure 2-16. Hail Product

Hail Temperature Height Selection

The 0°C and -20°C heights used by the Hail Algorithm can be entered at the ORPG HCI under the Environmental Data, to allow (under URC authority) the operator to input the most recent altitudes (see Fig. 2-17). These values should be obtained from representative sounding information. If no recent nearby sounding is available, a forecast sounding or interpolation from surrounding soundings is recommended. **This should be done twice daily or as meteorological conditions warrant for the algorithm to provide accurate hail estimates.**

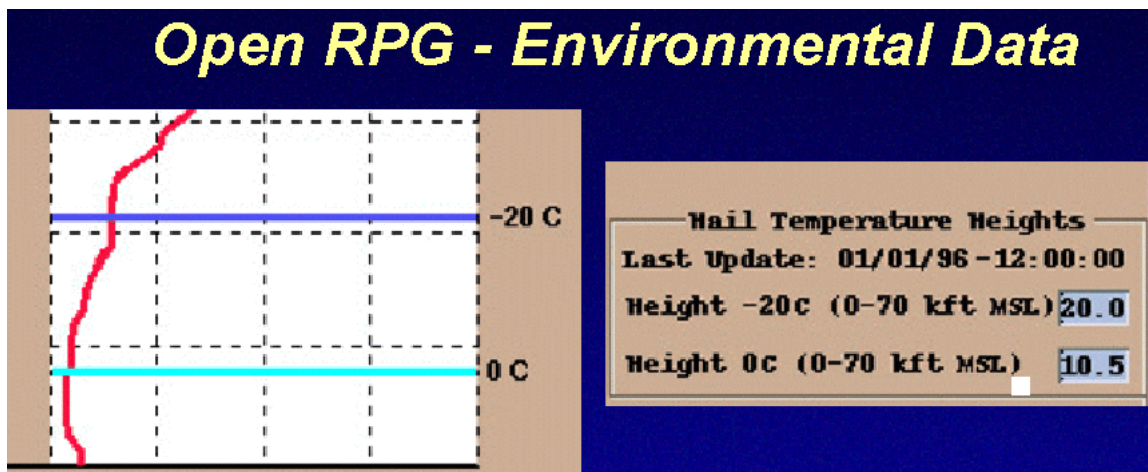


Figure 2-17. Hail Temperatures edit screens at the ORPG HCI.

Limitations

1. The Hail Detection Algorithm needs as input, **accurate and timely measurements of the MSL altitudes for the 0°C and -20°C levels.** Failure to update this information will degrade the algorithm's performance.
2. Values of POH, POSH, and MEHS will **fluctuate at close ranges, especially in VCP 21,** due to gaps in coverage at higher elevation slices.
3. The values for POH, POSH, and MEHS may **fluctuate at longer ranges from the radar** due to the limited number of slices through the cell.

4. The maximum hail processing range is 124 nm. **For cells beyond 124 nm, hail will be identified as UNKNOWN.**

5. **POSH and MEHS tend to overestimate the chances and size of hail in weak wind and tropical environments.** The accuracy of the hail estimates partially depends upon the accuracy of cell (component) information.

MEHS is an estimation of the largest hail in the cell, and often times, most of the hail from a cell is smaller.

The operator has to keep in mind that the MEHS should only be used as a guide. Storm spotters and other operational means should be integrated into the warning decision.

The Hail Detection Algorithm has shown a very high probability of detection in cells that contain severe hail, especially greater than one inch diameter hail. **A POSH of 50% or greater has shown skill as a warning threshold.**

Strength / Application

Cell Trends

Cell Trends is a **display** of up to a 10 volume scan history of key parameters for any user selected algorithm-identified storm cell. Cell Trends is **not** a product from the RPG, but a display derived “on-the-fly” at AWIPS from information stored with the Storm Structure alphanumeric product.

Introduction

The Cell Trends display consists of four graphs which show up to a 10 volume scan history of the following parameters:

Format

	Upper Left: Cell Base/Top, Height of Centroid & Height of Max dBZ
	Lower Left: Cell-Based VIL and Maximum Reflectivity
	Lower Right: Probability of Severe Hail (POSH), Probability of Hail (POH)
Display Definitions	<p>Cell Top-Base (Kft) -- The height (ARL) of the highest/lowest cell components.</p> <p>Centroid Height (Kft) -- The height (ARL) of the 3-D center of mass of the cell.</p> <p>Maximum Reflectivity Height (Kft) -- The height (ARL) of the component in which the highest reflectivity in the cell is detected (height of beam centerpoint at component's center).</p> <p>Cell-based VIL (KG/M²) -- VIL calculation integrating the maximum reflectivity of all cell components. Cell-based VIL should provide a more accurate assessment of VIL for fast-moving or strongly-tilted cells than the gridded VIL product (VIL - product ID #57). See the section on the SCIT algorithm.</p> <p>POSH/POH (%) -- Probability of Severe Hail (POSH) is the probability of hail greater than or equal to 3/4 inch. Probability of Hail (POH) is the probability of hail of any size. For more information see the Hail Detection Algorithm section.</p>
Cell Trend Request	Cell Trends is not a product, it has no product ID # or mnemonic, nor can it be archived. This display is generated by AWIPS, using data stored in the database with the Storm Structure product.

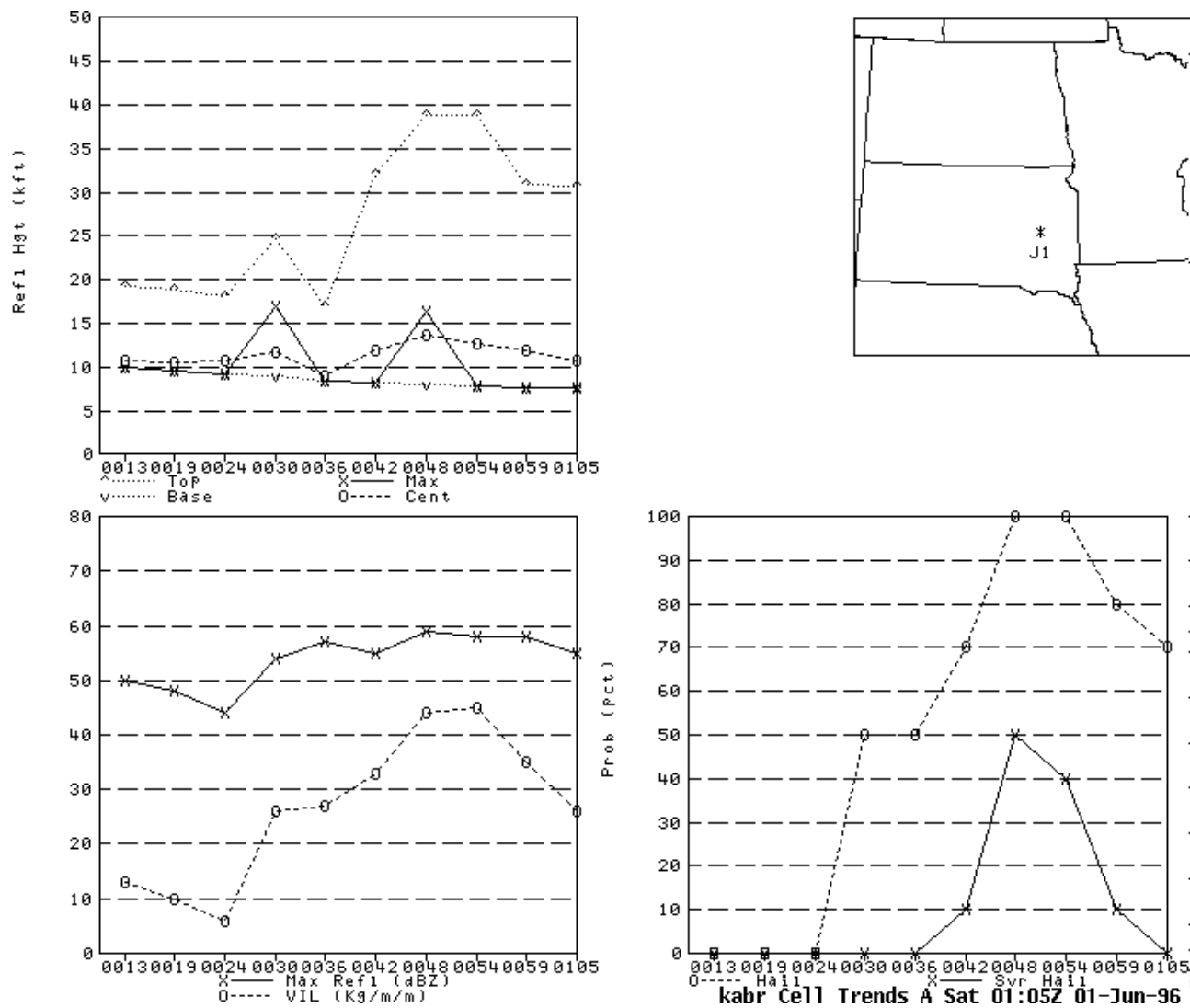


Figure 2-18. Cell Trends display.

Operators wishing to use the Cell Trends display frequently, should add the Storm Structure alphanumeric product (SS) to the current Routine Product Set (RPS) list. One-Time Requests can also be made for Storm Structure. A storm is selected by placing one of the Interactive Points near it. The Cell Trends graphic is displayed by accessing Graphics from the drop-down menu for one of your dedicated radars. From Graphics, the appropriate point is chosen under Cell Trends.

1. Errors in cell attributes often occur when cells are in close proximity. Trends of cell

Limitations

attributes may be misleading anytime cells are in close proximity.

2. Gaps between higher angles in VCP 21 can adversely affect the cell attributes tracked on the Cell Trends display. It is even possible that a trend of increasing or decreasing cell intensity may be displayed, when in fact the cell is not changing intensity. The Cell Trend display will be most accurate using VCP 11, which has fewer gaps between elevation slices. This limitation is included in the SCIT algorithm section.

Strength / Application

A large amount of information on an individual cell is displayed on a single easy-to-interpret display. For isolated cells that are greater than 20 nm from the RDA, Cell Trends provides a reasonably accurate view of cell evolution.

Lesson 3: Reflectivity Based Products

1. Vertically Integrated Liquid
2. Severe Weather Probability
3. Reflectivity Cross Section
4. Composite Reflectivity
5. Composite Reflectivity Contour
6. Layer Composite Reflectivity Maximum
7. Layer Composite Reflectivity Average
8. LRM Anomalous Propagation Removed (APR)
9. Echo Tops
10. Echo Tops Contour

Without references and according to the lesson, you will be able to ***identify one strength and one limitation of the following products:***

- 1) Vertically Integrated Liquid
- 2) Reflectivity Cross Section
- 3) Composite Reflectivity
- 4) Layer Composite Reflectivity Maximum
- 5) Echo Tops

VIL values represent reflectivity data converted into equivalent liquid water values.
What you are really viewing is integrated reflectiv-

Reflectivity Related Products

Objectives

Vertically Integrated Liquid (VIL)

Process

ity, not a storm's precipitable water content, as was the original intent.

The VIL equation is:

$$M = 3.44 \times 10^{-3} Z^{4/7}$$

where M = liquid water content (g m⁻³)

Z = radar reflectivity (mm⁶ m⁻³)

The values are derived for each 2.2 x 2.2 nm grid box; then vertically integrated. VIL values are output in units of mass per area (kg m⁻²).

The algorithm ***assumes reflectivity returns are from liquid water.***

Reflectivity returns from hail are non-linear & would result in unrealistically high values, so all reflectivities greater than 55 dBZ are truncated to 55 dBZ.

VIL Product Parameters

See Figure 3-1 for an example of the VIL product.

VIL product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Vert Integrated Liquid
- DATE: Day of week, time, and date in UTC

VIL product annotations

- VCP: 11, 21, 31 or 32
- MX: This is the maximum value in kg/m². The location of this value is unknown.

IC 5.5 WSR-88D Derived Products

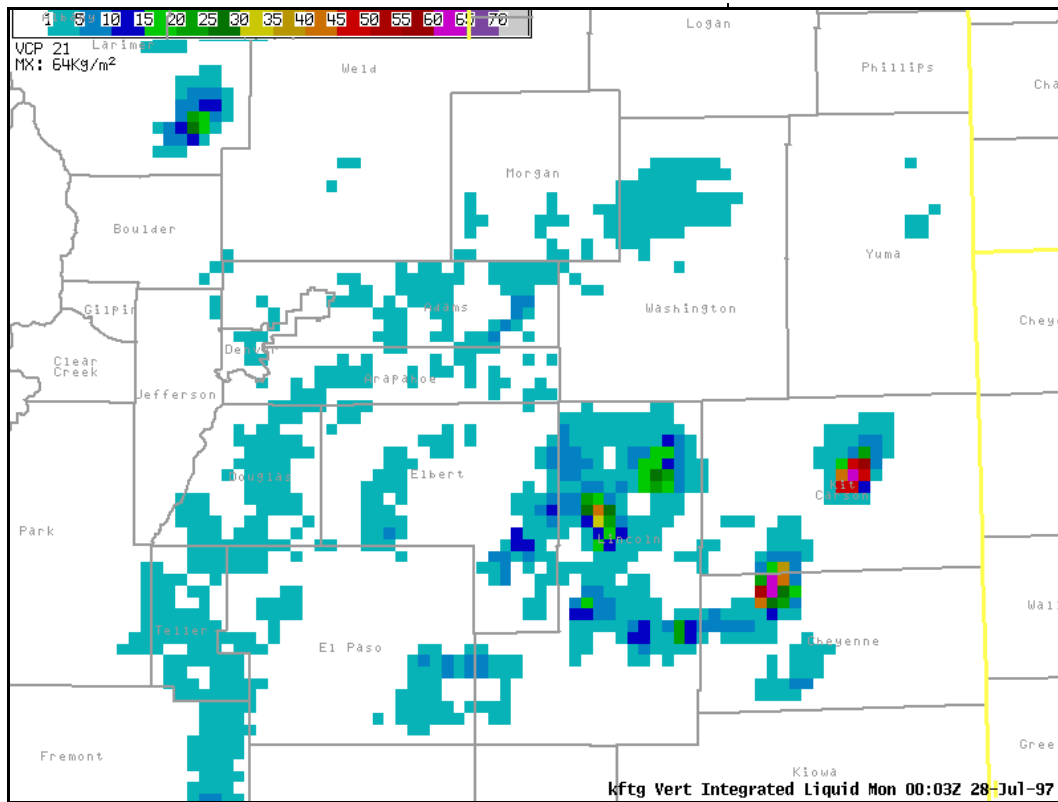


Figure 3-1. Vertically Integrated Liquid (VIL) product

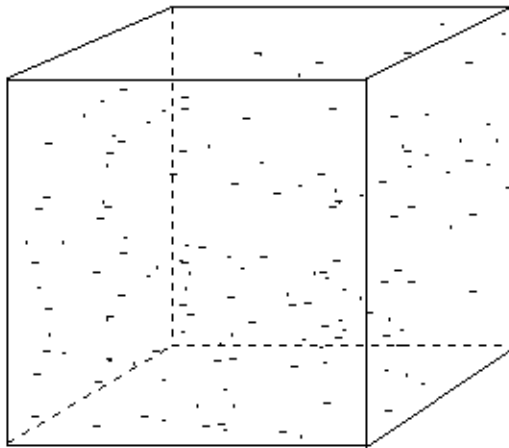
Additional VIL product characteristics

- RANGE: 124 nm
- RESOLUTION: 2.2 x 2.2 nm
- DATA LEVELS: Data level values range from 1 kg/m² to 70 kg/m².

1. VIL values are biased by drop size.
2. Values for warnings may change daily and across the *warning area*. Values are airmass dependent.
3. Values within 20 nm of radar are underestimated. This is due to the cone of silence.

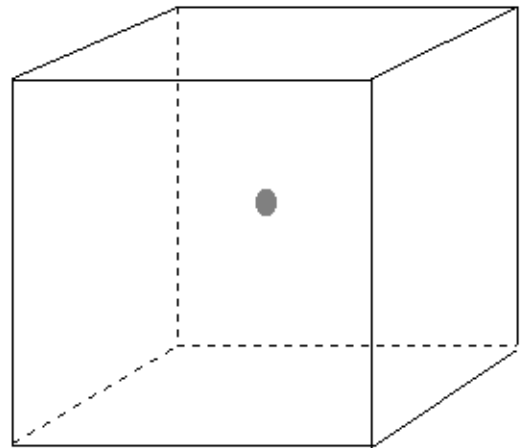
VIL Limitations

Same Reflectivity Different Rainfall Rate



729 One mm drops falling at 4 m/sec

$Z = 29 \text{ dBZ}$ $R = 0.22 \text{ in/hr}$



1 Three mm drop falling at 7 m/sec

$Z = 29 \text{ dBZ}$ $R = 0.01 \text{ in/hr}$

Figure 3-2. Effect of drop size on target reflectivity

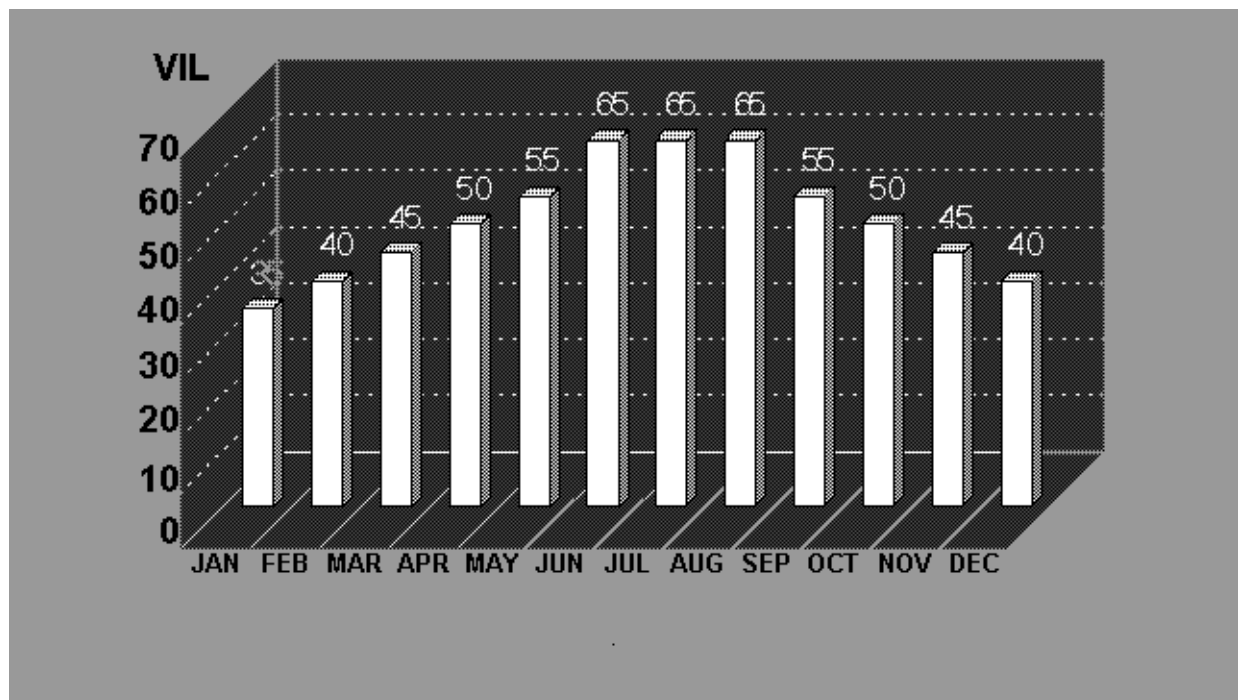
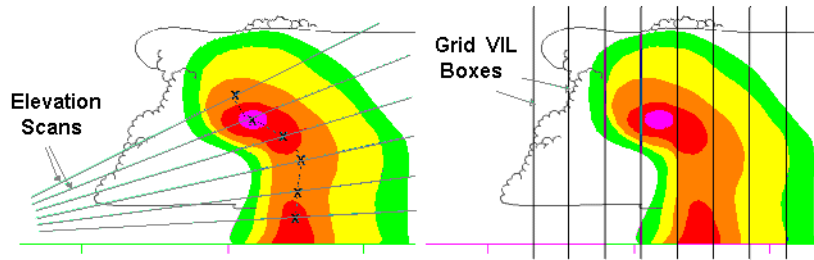


Figure 3-3. Estimated VIL values needed for large hail in Oklahoma.



Cell Based VIL

Grid Based VIL

Figure 3-4. Cell-based vs. Grid-based VIL.

4. Grid VIL values will differ from Cell-Based VIL values.
5. VIL values for a strongly tilted or a fast moving storm will be **lower** than if the storm was vertical or moving slower. The upper portion of the storm may extend into another grid box.
6. May be contaminated by non-precipitation echoes.
7. **Less VIL fluctuation with VCP 11 than VCP 21.** There are fewer gaps in VCP 11. This is mainly within 60 nm of the radar. This study is of observed VIL values.:
8. Values at distant ranges (≥ 110 nm) are occasionally **unreliable**. The reflectivity value at 0.5° is integrated down to the ground. At distant ranges the beam may be cutting through the highly reflective hail cores in the mid levels of a storm producing an overestimation of VIL. With very low- topped convection VIL values may be underestimated at long ranges.
1. Locate the most significant storms.
High VIL values correspond to deep areas of high reflectivity indicative of strong updrafts. VIL Density (VIL divided by Echo Tops - see Amburn and Wolf (1997)¹) has also shown skill indicating significant storms. Limitations of VIL previously listed (e.g., storm tilt and fast moving

VIL Strengths/ Applications

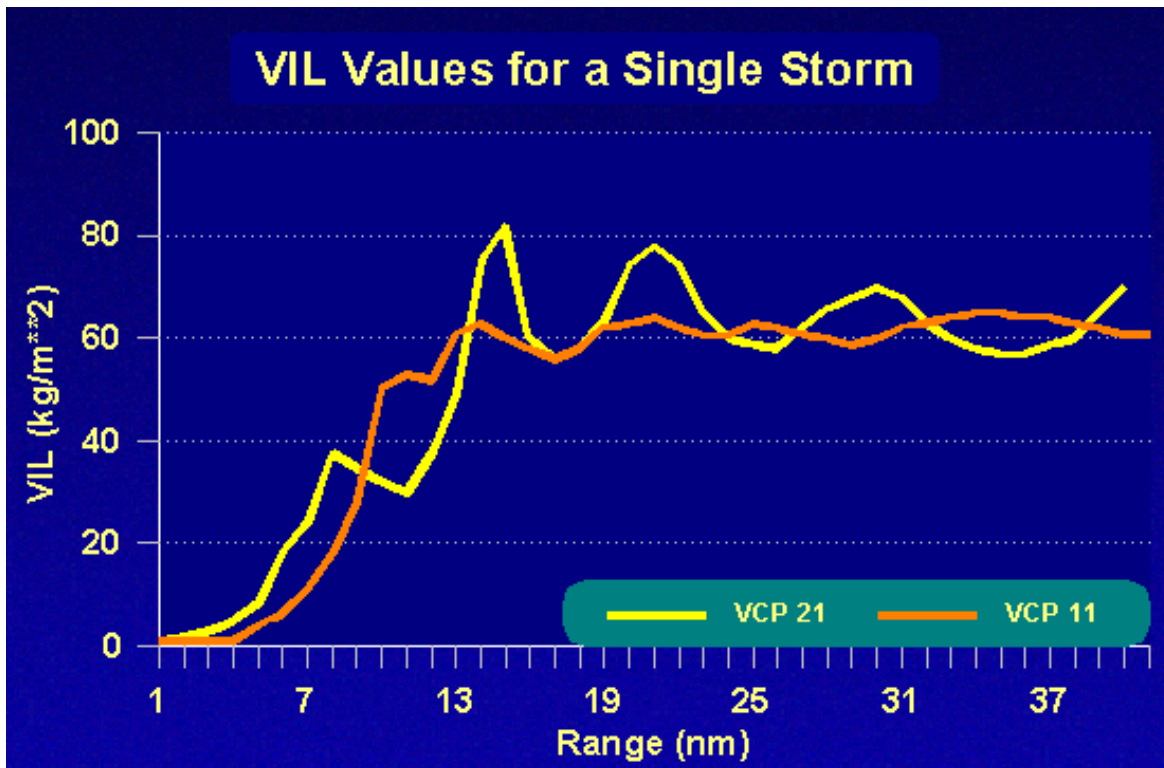


Figure 3-5. This study is from measurements of a single storm using two different volume coverage patterns. The results of the study show that a storm moving toward or away from the RDA will have more fluctuation in VIL values in VCP 21 than in VCP 11. This is due to the fact that there are more gaps in VCP 21 than in VCP 11. This effect is most noticeable within 60 nm of the RDA.

storms) and Echo Tops (later in this lesson) should always be considered when using these values.

2. Useful for distinguishing storms with large hail once threshold values have been established. Establishing a VIL of the Day using climatological data and/or sounding data (e.g., see Paxton and Shepherd (1993)²) can be of some limited use for initial development, but better skill can be achieved by real-time comparison between VIL values and spotter reports. As with all algorithm output, VIL alone should never be used as a warning criteria.
3. Persistent high VIL values associated with supercells. The exception is mini-supercell

thunderstorms or LP Supercells (see Burgess et al (1995)³).

4. Rapid decrease in VIL values may signify the onset of wind damage.

Use caution with this technique. It is important to know which VCP is being used because of gaps in the coverage in VCP 21. For more information see An Overview of Operational Forecasting for Wet Microbursts by William P. Roeder (45th Weather Squadron, USAF Cape Canaveral, FL) on the WDTB Web page

<http://www.wdtb.noaa.gov/workshop/psdp/Roeder/index.htm>

Only input is from gridded VIL Algorithm output. Most effective in indicating stronger storms.

SWP uses VIL values from each 2.2 x 2.2 nm grid box. Odd multiples of VIL boxes ranging from 3 x 3 boxes (6.6 x 6.6 nm) to 25 x 25 boxes (55 x 55 nm) are used as input into the equation. The default box size is 7 VIL boxes x 7 VIL boxes. (15.4 nm x 15.4 nm).

1. Arranges all VILs from highest to lowest values.
2. Puts first box around highest VIL.
3. Continues to put boxes around all VILs greater than 10 which are not already in a box. (boxes may overlap)

¹Amburn, Steven A., Peter L. Wolf, 1997: **VIL Density as a Hail Indicator.** *Weather and Forecasting*: Vol. 12, No. 3, pp. 473—478.

²Paxton, C. H., and J. M. Shepherd, 1993: Radar diagnostic parameters as indicators of severe weather in central Florida. *NOAA Tech. Memo. NWS-SR 149*, 12 pp.

³Burgess, D. W., R. R. Lee, S. S. Parker, D. L. Floyd, and D. L. Andra Jr., 1995: A study of mini supercells observed by WSR-88D radars. Preprints, *27th Conf. on Radar Meteorology*, Vail, CO., Amer. Meteor. Soc., 4—6.

Severe Weather Probability (SWP)

Process

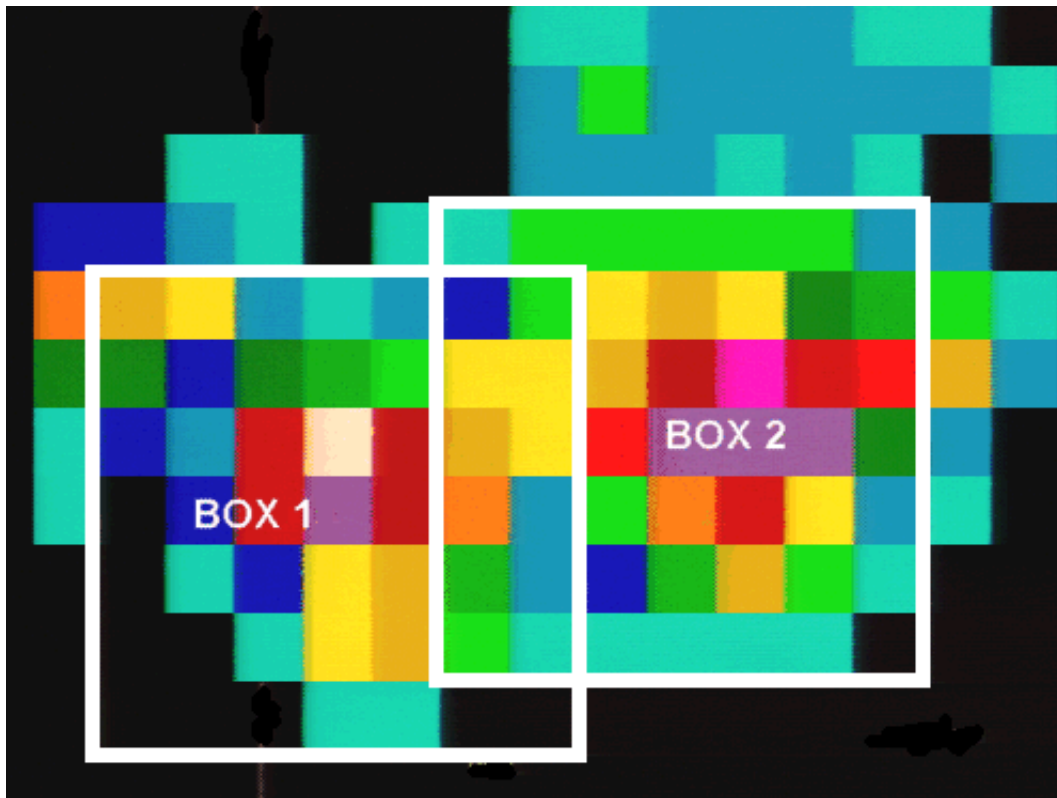


Figure 3-6. 7 x 7 VIL Boxes are the default size used with the current equation

$$SWP = 5.820 + 0.046a - .964b - .576c$$

where a = Number of VIL boxes x max VIL value

b = Number of VIL boxes > 10

c = Number of VIL boxes > 20

The index is proportional to the probability that a storm will produce severe weather within the next 30 minutes. ***DO NOT use as the actual probability that a storm is severe!!!***

Use other products with the Severe Weather Probability product to issue warnings.

- Base Reflectivity and Velocity

- Cross Sections
- Composite Reflectivity
- VIL
- Hail
- Cell Trend display

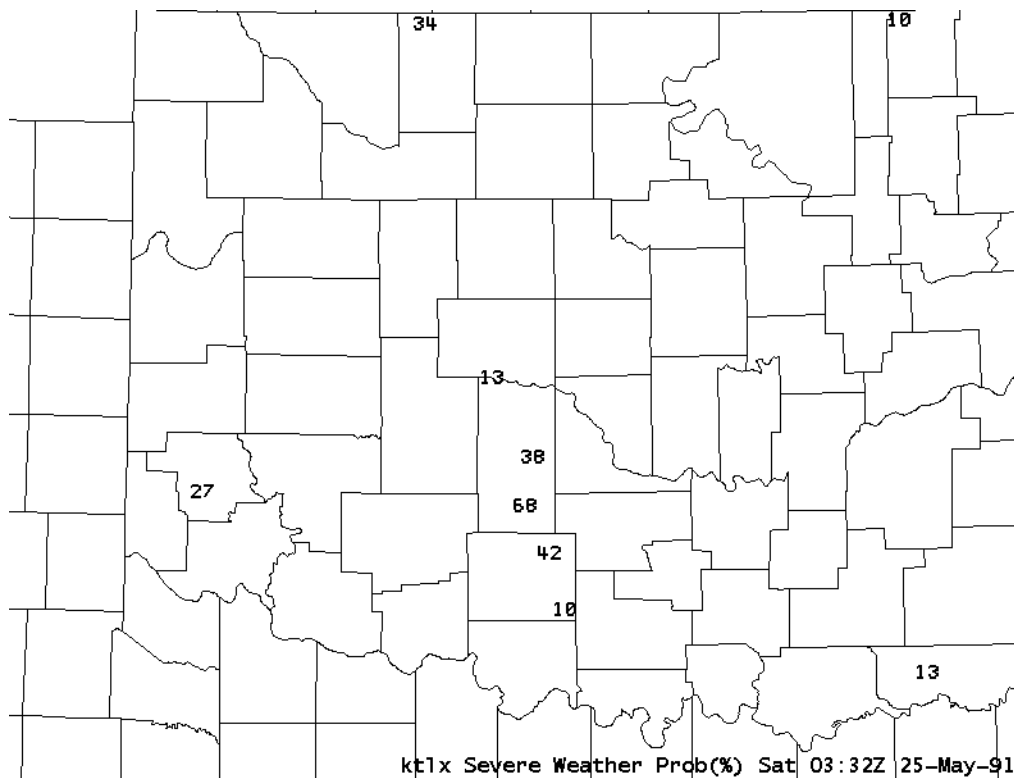


Figure 3-7. Severe Weather Probability product.

SWP product legend description:

- RPG ID: kxxx
 - PRODUCT NAME: Severe Weather Prob (%)
 - UNITS: Percent (%)
 - DATE: Day of week, time, and date **in UTC**
1. Only incorporates VIL; no environmental conditions considered.
 2. Threshold values for severe storms will vary in differing climatological areas. Each site will have to adjust probabilities.

SWP Product

SWP Limitations

SWP Strength/ Application

Reflectivity Cross Section (RCS)

Process

3. If VIL values inconsistent; SWPs also inconsistent.
4. May be contaminated by non-precipitation echoes.

1. Quick identification of strongest storms.

The WSR-88D can generate a cross-section between any two points within a 124 NM range as long as the points are no greater than 124 nm apart.

The cross section product is a volume product created by:

1. **Linking all elevation scans** using 0.54 nm base data.
2. **Interpolating vertically between elevation angles** where no data are collected (vertical resolution 0.27nm).
3. **No extrapolation is performed from highest or lowest elevation angle.** It uses beam center point height.

Cross section products are not recommended for RPS List since endpoints change constantly.

Product Request

Using Interactive Lines, the user places a line through a storm of interest. Lines are referenced by the letters assigned to the endpoints, e.g. A & A', B & B', etc. Since the RCS requires a full volume scan of data, it is usually generated using the previous volume scan, unless the request is made at the end of the current volume scan. See Figure

3-8 for an example of the request screen for the RCS product.

The user selects 2 points (AZRANS) which can be up to 124 nm apart, but within 124 nm of the RDA. On the cross section product, ENDPT1 is always on the left side, ENDPT2 is on the right. It doesn't matter in which order they are picked. ENDPT1 is defined as the western most point picked, unless along the same longitude, then ENDPT1 is the northern point. The RCS is created from the previ-

Product Interpretation

The screenshot shows a software window titled "Dedicated - One Time Request". Inside, there are several input fields and buttons:

- Repeat count:** A numeric field set to "1".
- RPG:** A dropdown menu showing "KFDR".
- Product:** A dropdown menu showing "Ref X- Sect (RCS)".
- Priority:** A dropdown menu showing "Low".
- Request Interval:** A numeric field set to "1".
- Baseline:** A dropdown menu showing "C".
- Length:** A text field showing "69.4629 nMi".
- Buttons:** "Load Baselines" (next to Length), "Change..." (next to Selected time), "Send", and "Close".
- Time:** Radio buttons for "Current", "Latest" (selected), and "Selected".
- Selected time:** A text field showing "Latest".

Figure 3-8. RCS product request screen

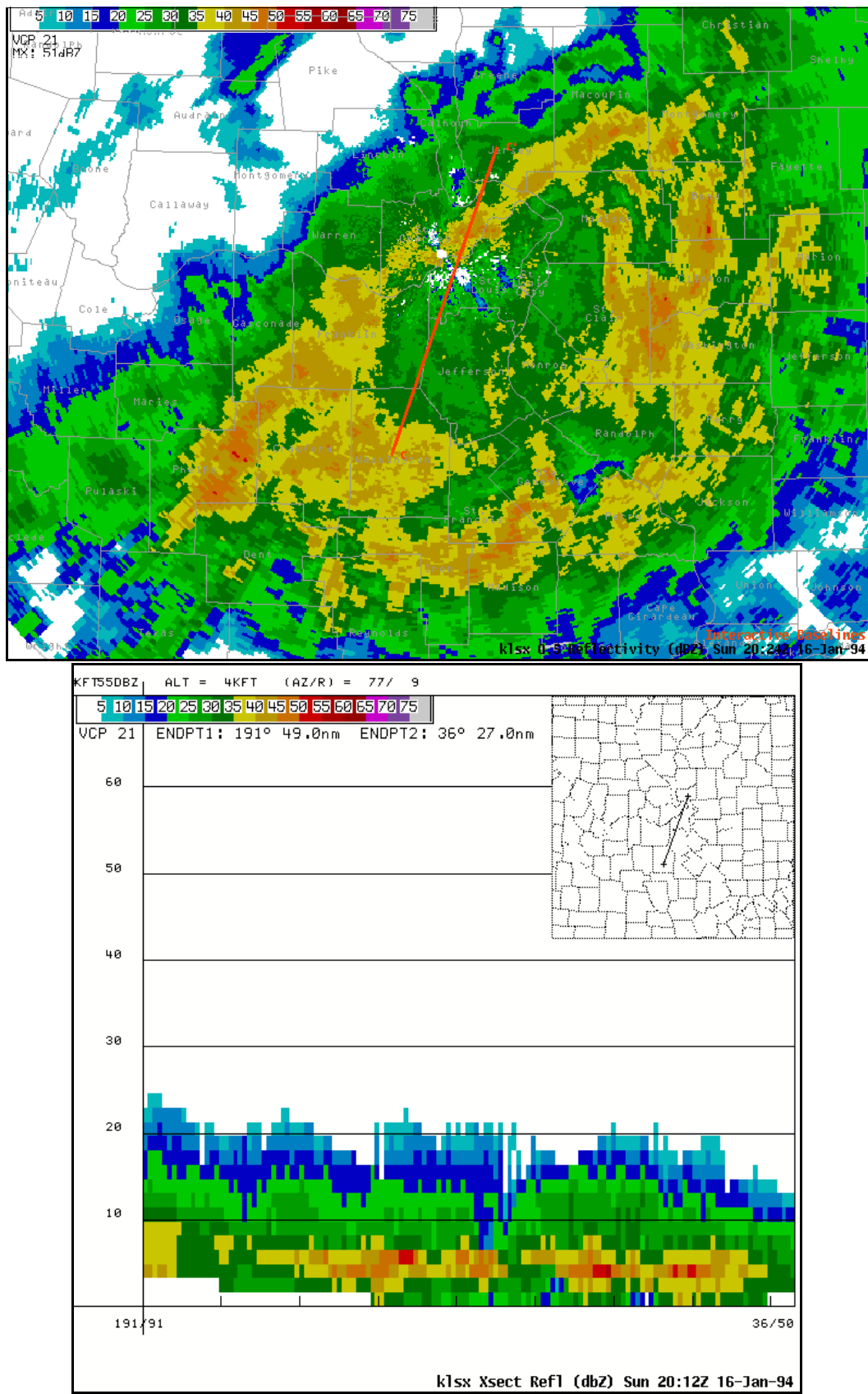


Figure 3-9. Top: Base Reflectivity overlaid with the interactive line used to generate the cross section. Bottom: Matching Reflectivity Cross Section

ous volume scan, unless it is requested at the end of the current volume scan.

- Height on Z axis is at 10,000 ft intervals (Above Radar Level (ARL)), which cannot be changed.
- Range on X/Y axis depends upon length of cross section. Endpoints in annotations area are in nm. Endpoints on the bottom of the cross section are in km prior to AWIPS Build 5.1.1 and nm in AWIPS Build 5.1.1 or after.

See Figure 3-9 for an example of the RCS product.

RCS product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Xsect Refl
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

RCS product annotations

- VCP: 11, 21, 31 or 32
- ENDPT1: This is the AZRAN of the western-most point.
- ENDPT2: This is the AZRAN of the eastern-most point.
- MAX (dBZ), ALT (Kft), (AZ/R): Max reflectivity in the cross section, its altitude and AZRAN.

1. Cross section placement may hamper evaluation of storm structure.

Product dimensions

Reflectivity Cross Section (RCS) Parameters

Reflectivity Cross Section Limitations

Reflectivity Cross Section Strengths/ Applications

2. ***Echo tops and bases are truncated***, no vertical extrapolation on the highest or lowest elevation angles.
 3. ***Height vs. range exaggeration***. The vertical extent of the product is 70,000 ft (~11.5 nm), while maximum range is 124 nm.
 4. ***Small features may be enlarged or missed due to interpolation***.
 5. ***Presentation of product dependent upon VCP. More coarse with VCP 21 than VCP 11***. Due to more gaps within 60 nm of the radar in VCP 21.
 6. ***Fast moving storms may appear to be strongly tilted***. Because of the time needed to complete a volume scan.
-
1. ***Detect the vertical extent of clouds/insects/smoke plumes***.
 2. ***Verify existence and location of a bright band***.
 3. ***Estimate height of higher dBZ's***. Placement is critical when attempting to estimate dBZ heights. Remember that 55 dBZ on the WSR-88D is about the same as 45-50 dBZ on conventional radars.
 4. ***Evaluate storm structure features***. Again, placement is critical in order to see features such as BWERs, WERs, and storm tilt.
 5. ***Estimate echo tops***. This product will display reflectivities down to 5 dBZ in precipitation mode.
 6. ***Monitor the formation/dissipation of precipitation events***.

Interim Summary

1. Knowledge of the meteorological environment is necessary to use product effectively.
2. Alerts operator to most significant storms.
3. Effective for detecting storms with 3/4 inch or larger hail.
4. Critical threshold values must be established for differing climatological regions.

1. Product represents a probability of a storm's severity, but should be used only as an index.
2. No environmental conditions are considered in statistical equation.
3. Use other products with SWP in making warning decisions.
4. Threshold values for severe storms will vary climatologically and seasonally.

1. Placement is critical to interpretation.
2. Determine storm structure features such as updraft flank, tilt, storm top, WERs, BWERs, and the vertical extent of higher reflectivities.
3. Cross sections must be within 124 nm of radar with a maximum length of 124 nm.

Vertically Integrated Liquid (VIL)

Severe Weather Probability (SWP)

Reflectivity Cross Section (RCS)

Composite Reflectivity (CR)

The CR product displays the highest reflectivity for each grid box for all elevation angles.

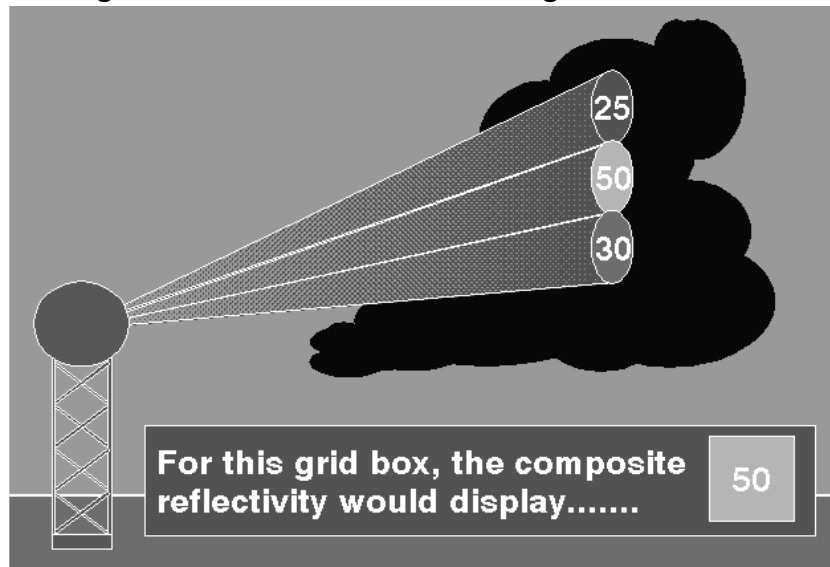


Figure 3-10. Composite Reflectivity

Resolution

- 1 km x 1 km (.54 x .54 nm) range 124 nm
- 4 km x 4 km (2.2 x 2.2 nm) range 248 nm

Note: There is *no* 2 km (1.1 nm) resolution product

The CR product is effective for detecting higher reflectivities aloft.

Combined Attribute Table

The Combined Attribute Table is only available on the Composite Reflectivity and Composite Reflectivity Contour Product (see page 52). The table contains output from the following algorithms:

1. SCIT
2. HDA
3. TVS
4. MESO

Some outside users are only able to access TVS and MESO detections using the Combined Attribute Table. This can lead to confusion since the table only includes azimuth and range to the **storm cell centroid**, not the TVS or MESO location.

The Combined Attribute Table includes:

- **STM ID** - Cell ID letter/number
- **AZ/RAN** - Azimuth and Range of **cell centroid**
- **TVS** - Yes if TVS is present or No
- **MESO** - Yes or no for MESO only. It will always be no for 3-D Correlated Shear, or Uncorrelated Shear.
- **POSH / POH / MX SIZE** - Probability of Severe Hail / Probability of Hail / Max Hail Size
- **VIL** - Cell Based VIL
- **DBZM HT** - Maximum reflectivity (dBZ) and height of maximum reflectivity (Kft)
- **TOP** - Height of upper most component (Kft)
- **FCST MVMT** - Forecast movement (deg./ kts)

1. TVS or ETVS
2. Mesocyclone, 3DC Shear, Uncorrelated Shear
3. Probability of Severe Hail (POSH)
4. Probability of Hail (POH)
5. Cell based VIL

Note: Cells with unknown POSH or POH (i.e., cells beyond 124nm), yet high cell based VIL, may end up at the bottom of the Combined Attribute Table.

Order of storms

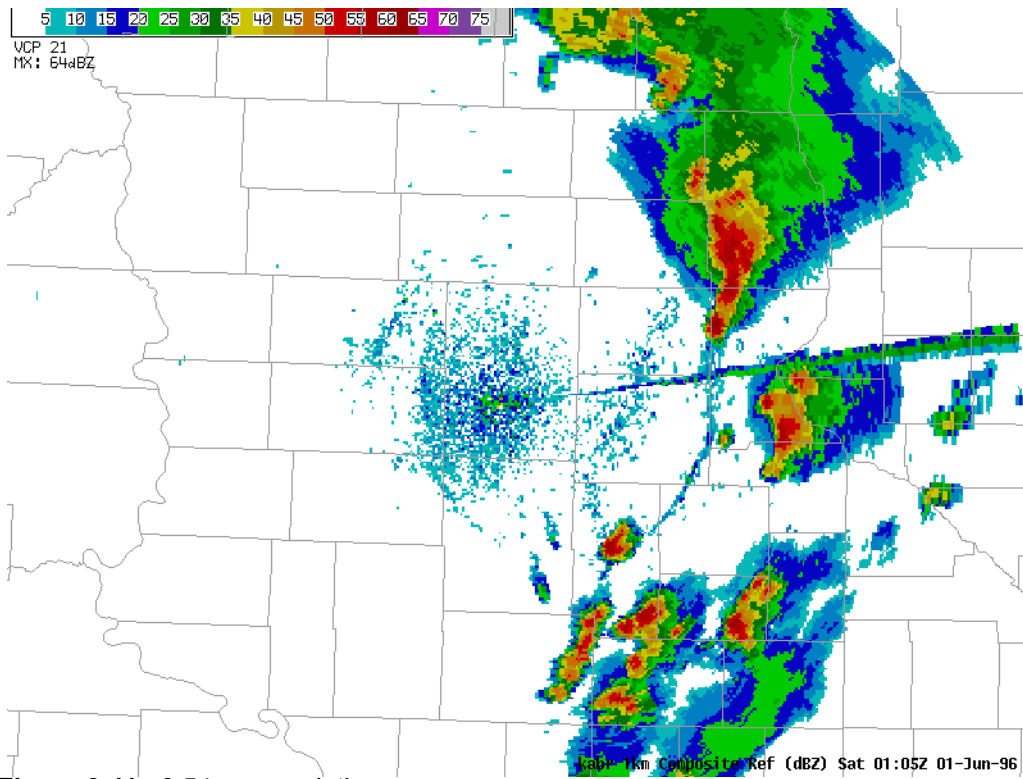


Figure 3-11. 0.54 nm resolution.

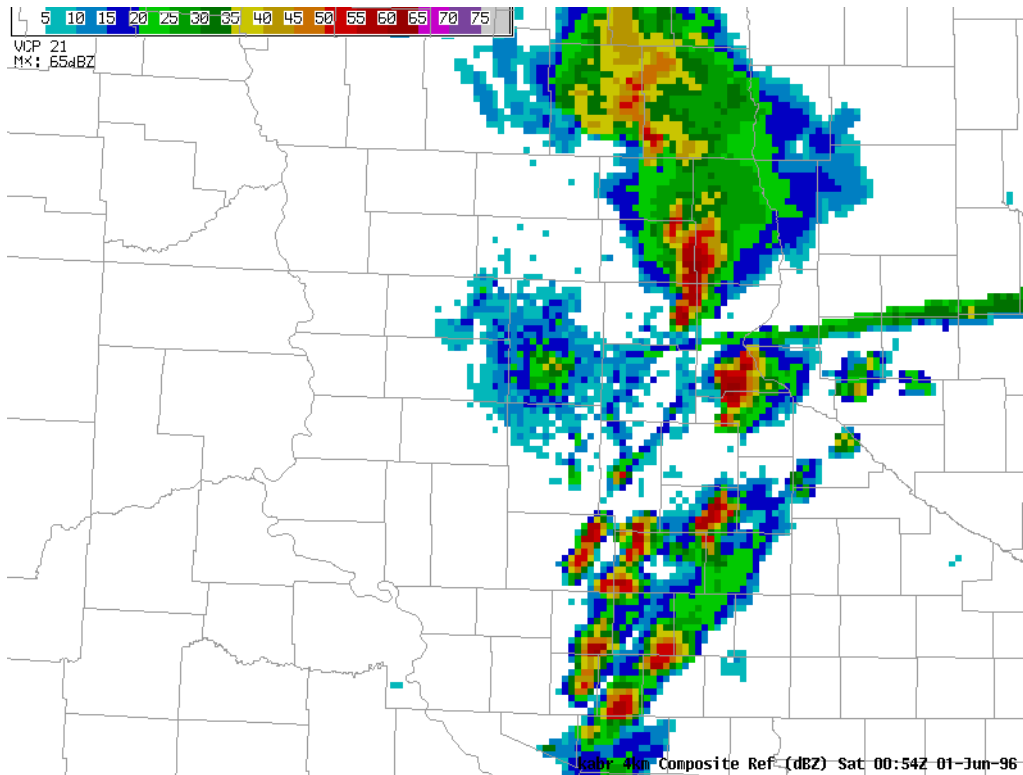


Figure 3-12. 2.2 nm resolution

See Figure 3-11, 3-12, and 3-13 for examples of the CR product.

Composite Reflectivity (CR) Product

CR product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Composite Ref
- UNITS: dBZ
- DATE: Day of week, time and date in UTC

CR product annotations

- VCP: 11, 21, 31 or 32
- MX: This is the maximum reflectivity (dBZ) on the product, with the location unknown. This value will not change when zoomed in on a feature, as it is the maximum value for the entire product.

Additional CR product characteristics

- RANGE: 124 or 248 nm
- RESOLUTION: .54 or 2.2 nm, respectively
- DATA LEVELS: 16 data levels - values range from 5 to 75 dBZ

- 1. Low level reflectivity signatures are obscured.**
- 2. Height of reflectivity is unknown.**
- 3. Echo aloft can't be discriminated from precipitation reaching the surface.**
- 4. Non-precipitation echoes may contaminate product.**

Composite Reflectivity Limitations

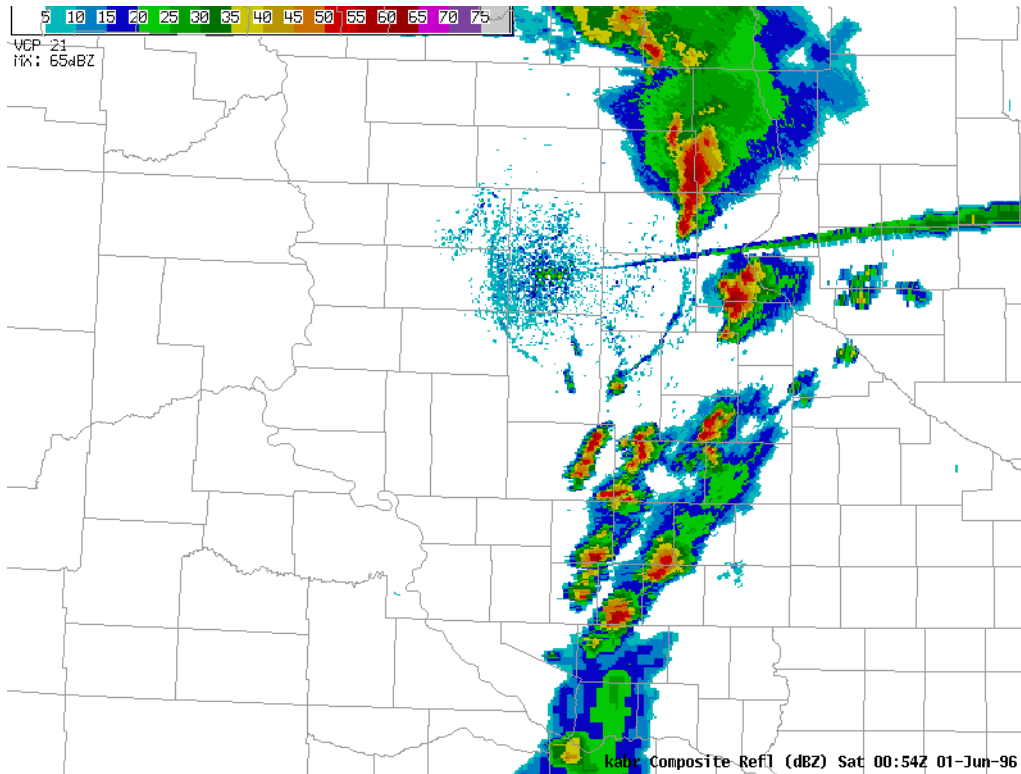


Figure 3-13. Composite Reflectivity (CR) product showing both resolutions.

Composite Reflectivity Strengths / Applications

1. Reveals highest reflectivity in all echoes.
2. Determine storm structure features & intensity trends in storms. (When compared with base products).
3. Generate cross sections through maximum reflectivity knowing the inflow side of storm. The operator will have more predictable results with a .54 nm product.
4. The Combined Attribute Table is available.

Composite Reflectivity Contour (CRC)

Line-contoured image of Composite Reflectivity

Contouring by addition of vectors - The grid points are first reduced in resolution from 1 km to 2 km. Smoothing is then performed on the data. Contouring begins at the lowest contouring value to be drawn and works its way up in value.

Contour intervals and lowest data level are changed at the ORPG HCI.

Contour interval default - 5 dBZ (Valid intervals are from 2 to 20 dBZ).

Combined Attribute Table available

1. Interpretation difficult
2. Non-precipitation echoes may contaminate product
3. Contour lines may just end or higher values may not be available if the product gets too big.

1. Contoured image of Composite Reflectivity product
2. Combined Attribute Table is available.

These two products display the **maximum** or **average** reflectivities for a layer.

These 2 products have similar characteristics including:

Three layers

- **Low** - User-defined (Sfc - 18K) to 24,000 ft
- **Mid** - 24,000 ft to 33,000 ft
- **High** - 33,000 ft to 60,000 ft

With the exception of the base of the lowest layer, no changes can be made to alter the depths of these products unless authorized by ROC.

Originally developed for CWSU/FAA use.

Desired product layers (L,M,H) can be specified on the RPS list or one time request.

Composite Reflectivity Contour Limitations

Composite Reflectivity Contour Strengths/ Applications

Layer Composite Reflectivity Maximum (LRM) & Layer Composite Reflectivity Average (LRA)

Resolution 2.2 x 2.2 nm; Coverage 248 x 248 nm.

Available with 8 data levels only.

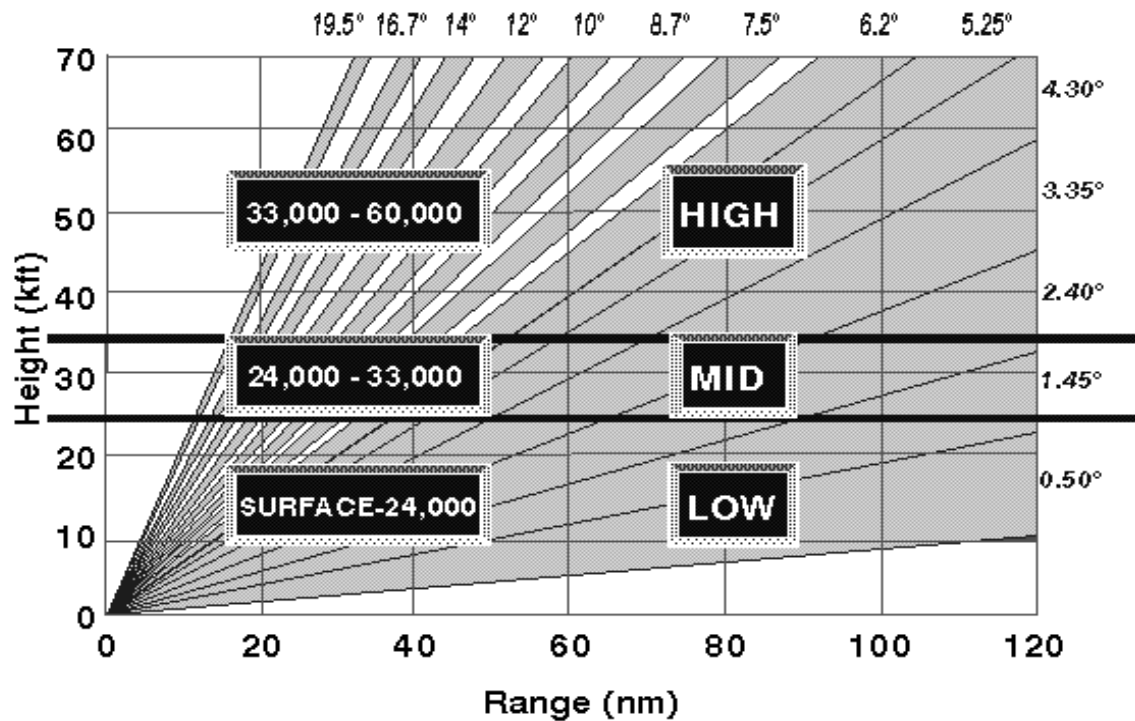


Figure 3-14. Layer Composite Reflectivity Default Layers (VCP 11)

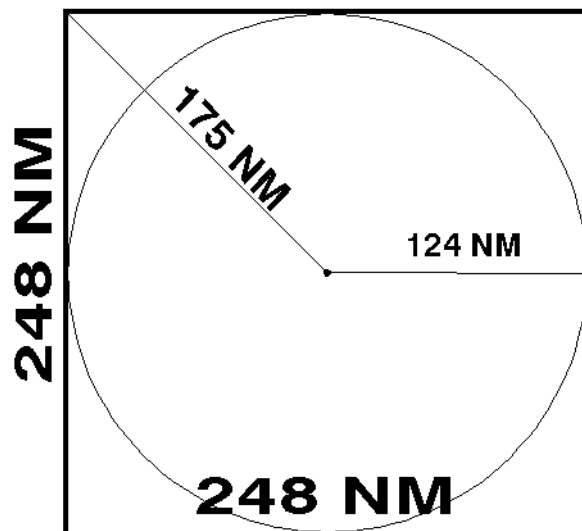


Figure 3-15. LRM/LRA Product size.

Layer Composite Reflectivity Maximum - Displays the highest reflectivity value of all elevation angles contained in that layer for each 2.2 x 2.2 nm grid box.

Layer Composite Reflectivity Average - Displays the averaged reflectivity value of all elevation angles contained in that layer for each 2.2 x 2.2 nm grid box.

Only the two lowest elevation angles were used for a certain 2.2 x 2.2 nm grid box on the low level Layer Composite Reflectivity products. What would be the layer composite reflectivity average & maximum for the grid box?

<u>Degrees</u>	<u>.54 nm resolution dBZ values</u>
0.5	42, 44, 46, 48
1.5	50, 52, 54, 56

LRM -max reflectivity= 56 dBZ

LRA -avg reflectivity= $392/8 = 49$ dBZ.

See Figure 3-16 for an example of the LRM product.

LRM product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Layer 1 Max Refl
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

Layer Composite Reflectivity Product Definitions

Example

LRM Product Parameters

LRM product annotations

- VCP: 11, 21, 31 or 32
- BOT: Bottom of the layer in kft, which is user selectable (Figure 3-16)
- TOP: Top of the layer in kft, which is fixed at 24 kft.
- MX: This is the maximum reflectivity (dBZ) on the product, with the location unknown. This value will not change when zoomed in on a feature, as it is the maximum value for the entire product.

Additional LRM product characteristics

- RANGE: 124 nm
- RESOLUTION: 2.2 x 2.2 nm

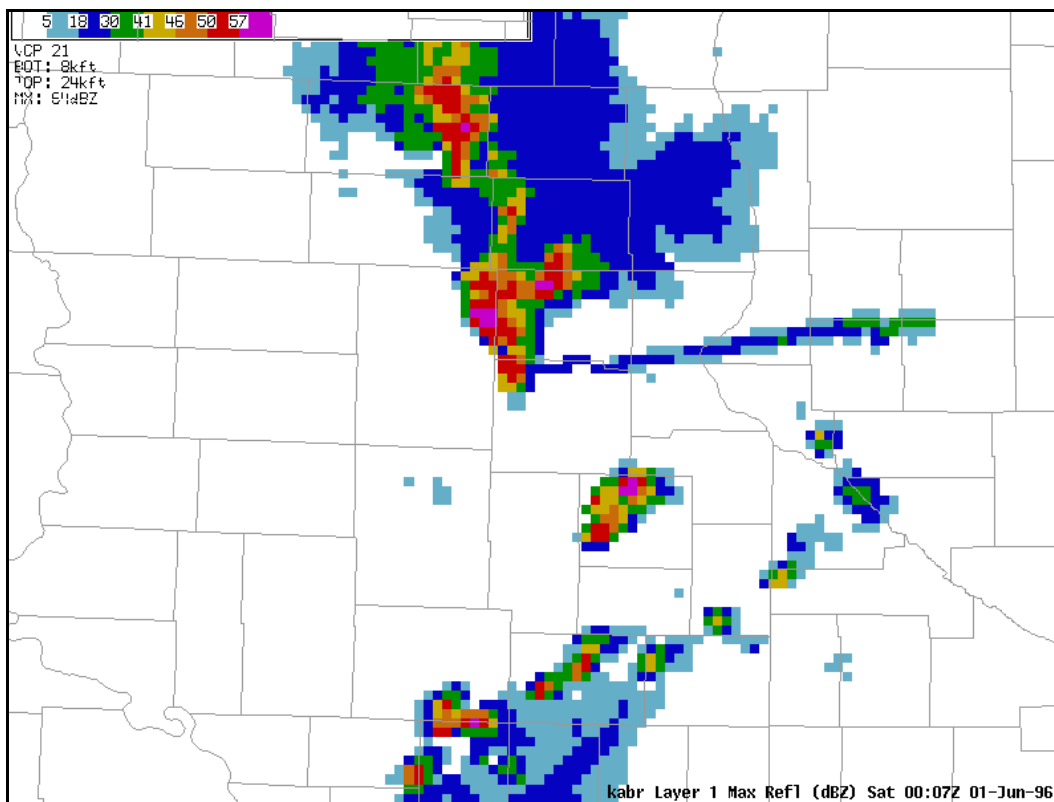


Figure 3-16. Layer Composite Reflectivity Maximum (LRM) product - low layer with base at 8,000 ft MSL.

- DATA LEVELS: Data level values range from 5 to 57 dBZ

1. Mid & Low layer products will use few elevation angles at long distances.
2. Mid and High level products are ineffective at close range due to the cone of silence.
3. Low layer product susceptible to non-precipitation echoes.

Layer Reflectivity Product Limitations

1. Mid-High layer products used to estimate the height of higher reflectivities.
2. Comparison of Base Reflectivity and Mid or High Layer Composite Reflectivity Maximum product may aid in determining a storm's intensity trend.
3. Use mid level product to help differentiate real echoes from ground clutter.

Layer Reflectivity Strengths/ Applications

LRM - Anomalous Propagation Removed (APR) Product

The Layer Composite Reflectivity Maximum - Anomalous Propagation Removed product (APR, ID# 67) is an 8-data level reflectivity display similar in appearance to the Layer Composite Reflectivity Maximum (LRM) products. The APR product does not replace any of the LRM products. It is derived from the output of an algorithm which processes base reflectivity, velocity, and spectrum width data with the goal of distinguishing between meteorological returns and returns from ground clutter/AP. The algorithm will generate a Surface to 24,000 ft Layer Composite Reflectivity Maximum product every volume scan with the algorithm-identified ground targets removed.

Introduction

APR Algorithm

The algorithm used to identify and remove clutter was developed at **Lincoln Laboratories**, and is based on the observation that ground targets tend to affect mainly the lowest antenna tilts, and are typically associated with low radial velocity and low spectrum width.

The algorithm separates the atmosphere into three regions based on distance from the RDA, and altitude above the surface. A different clutter removal technique is applied to each region, based on known observations of the appearance and location of clutter.

The ***Omit All*** region is defined as that portion of the atmosphere within 45 km of the RDA, and below 1 km in altitude. All targets in the *Omit All* region are considered clutter and are removed (see Fig. 3-17).

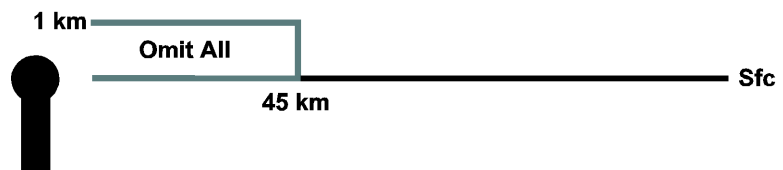


Figure 3-17. Omit All Region.

The ***Accept If*** region is defined as that portion of the atmosphere within 103 km of the RDA, at 0.5° and below 3 km in altitude, and not within the Omit All region. A target in the *Accept If* region is displayed if its velocity is ≥ 2.0 m/s **and** its spectrum width is ≥ 2.0 m/s. Essentially, a target in this region is assumed to be clutter, but it will be **accepted** as being meteorological **if** movement is indicated by either velocity or spectrum width data (see Fig. 3-18).

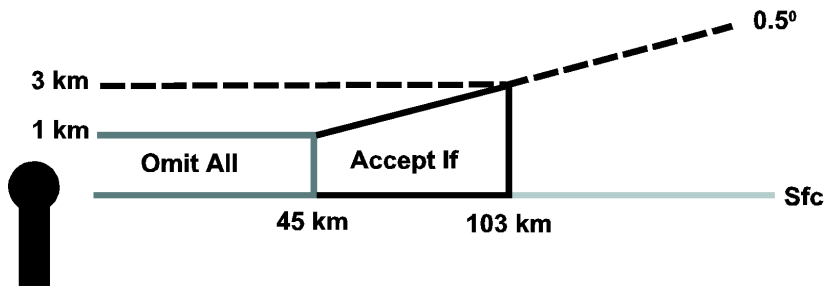


Figure 3-18. Accept If Region.

The ***Reject If*** region is defined as that portion of the atmosphere within 230 km of the RDA, below 5° in elevation, and not within either the Omit All or Accept If regions.

A target in the ***Reject If*** region is rejected if it possesses a velocity < 2.0 m/s and a spectrum width < 2.5 m/s. Essentially, a target in this region is assumed to be meteorological, but it will be ***rejected*** as being clutter ***if*** little or no movement is indicated (see Fig. 3-19).

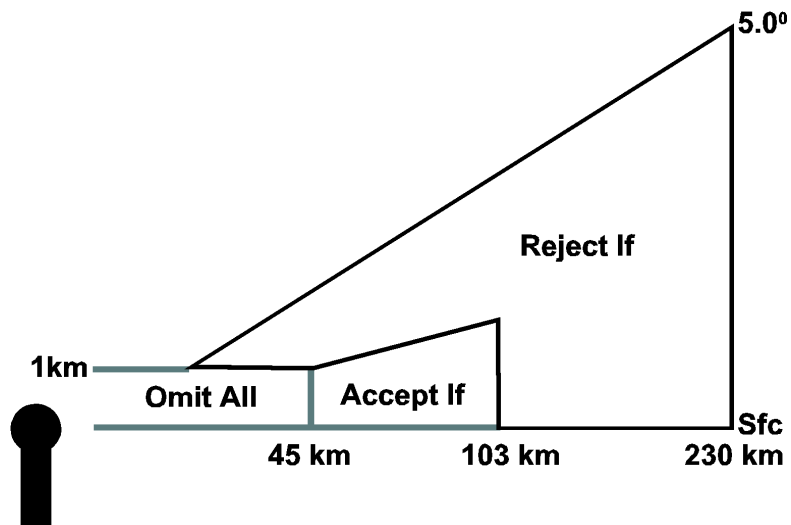


Figure 3-19. Reject If Region.

See Figure 3-20 for an example of the APR product.

APR product legend description:

**LRM - AP Removed
Product Parameters**

- RPG ID: kxxx
- PRODUCT NAME: Layer Max Refl--No AP
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

APR product annotations

- VCP: 11, 21, 31 or 32
- BOT: Bottom of the layer in kft, which is fixed at the surface
- TOP: Top of the layer in kft, which is fixed at 24 kft
- MX: This is the maximum reflectivity (dBZ) on the product, with the location unknown. This value will not change when zoomed in on a feature, as it is the max value for the entire product.

Additional APR product characteristics

- RANGE: 124 nm
- RESOLUTION: 2.2 x 2.2 nm
- DATA LEVELS: 8 Data levels - values range from 5 to 57 dBZ

Limitations

The algorithm works best if traditional clutter filtering is applied before the algorithm begins processing data. The algorithm assumes **all** low level data within 45 km is clutter, which may result in valid data being dropped from the product.

Strengths

The APR algorithm attempts to distinguish weather targets from clutter targets.

IC 5.5 WSR-88D Derived Products

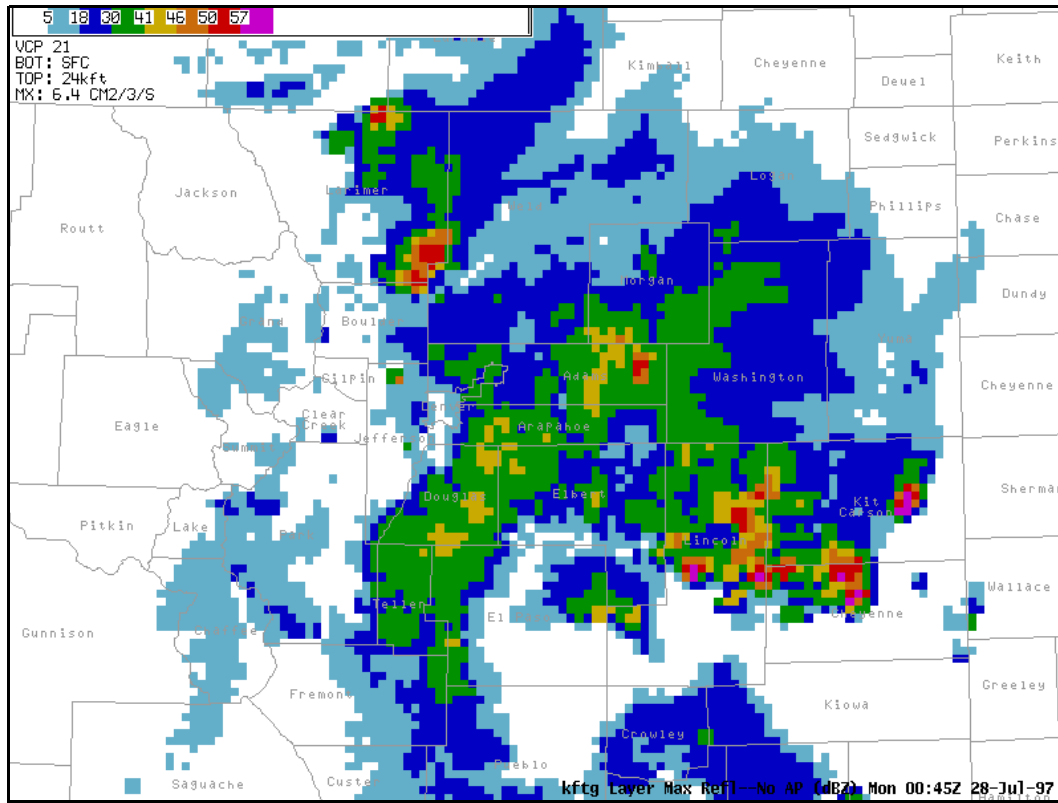


Figure 3-20. LRM-AP Removed product.

Interim Summary

Composite Reflectivity (CR)

1. Displays the maximum reflectivity for each vertical resolution grid box.
2. Useful product to:
 - quickly identify most intense storms, &
 - determine where to create Reflectivity Cross Sections.
3. Combined Attribute Table is available with product.

Composite Reflectivity Contour

1. Contoured image of Composite Reflectivity product.
2. More difficult to interpret than the Composite Reflectivity product.
3. Combined Attribute Table is available with product.

Layer Reflectivity Products

1. Maximum or average reflectivity for a specified layer.
2. Mid or high layer product used to estimate height of higher reflectivities
3. Comparison of mid or high layer products and Base Reflectivity may help determine the intensity trend of storms.

LRM - Anomalous Propagation Removed (APR)

1. Attempts to distinguish weather targets from ground targets.
2. Algorithm works best if traditional clutter filtering is applied.

Echo Tops (ET)

Definitions

Top - Height of highest component

Cloud Top - Height of the lowest displayed reflectivity (5 dBZ)

Echo Top - Height of the 18.3 dBZ echo

The Echo Top product locates the highest elevation angle where **reflectivity ≥ 18.3 dBZ** for each **2.2 x 2.2 nm grid box**.

Only available resolution is 2.2 x 2.2 nm.

The Echo Top algorithm measures height where reflectivity is ≥ 18.3 dBZ, then MSL height of RDA is added to echo top height.

A **circular stair-stepped appearance** can occur since the beam center point is used to measure the height. This is usually most noticeable with widespread precipitation at distant ranges.

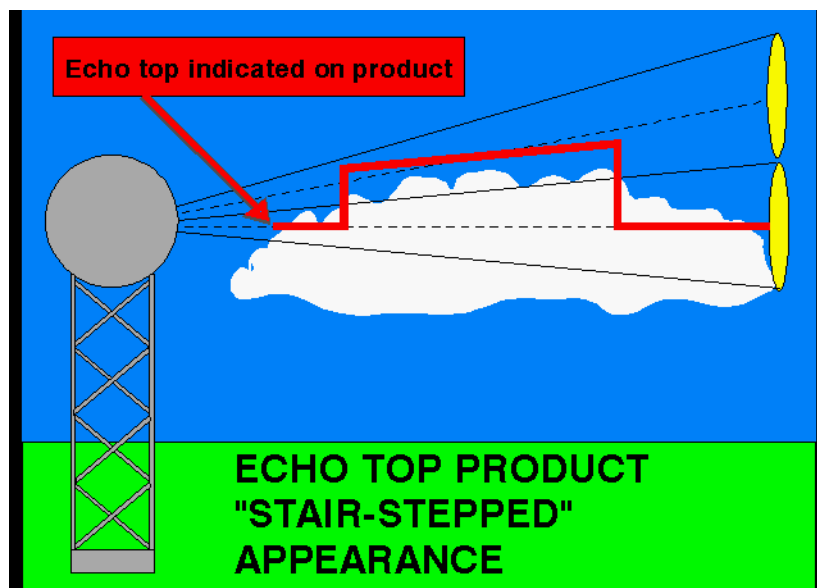


Figure 3-21. Echo Top product stair-stepped appearance.

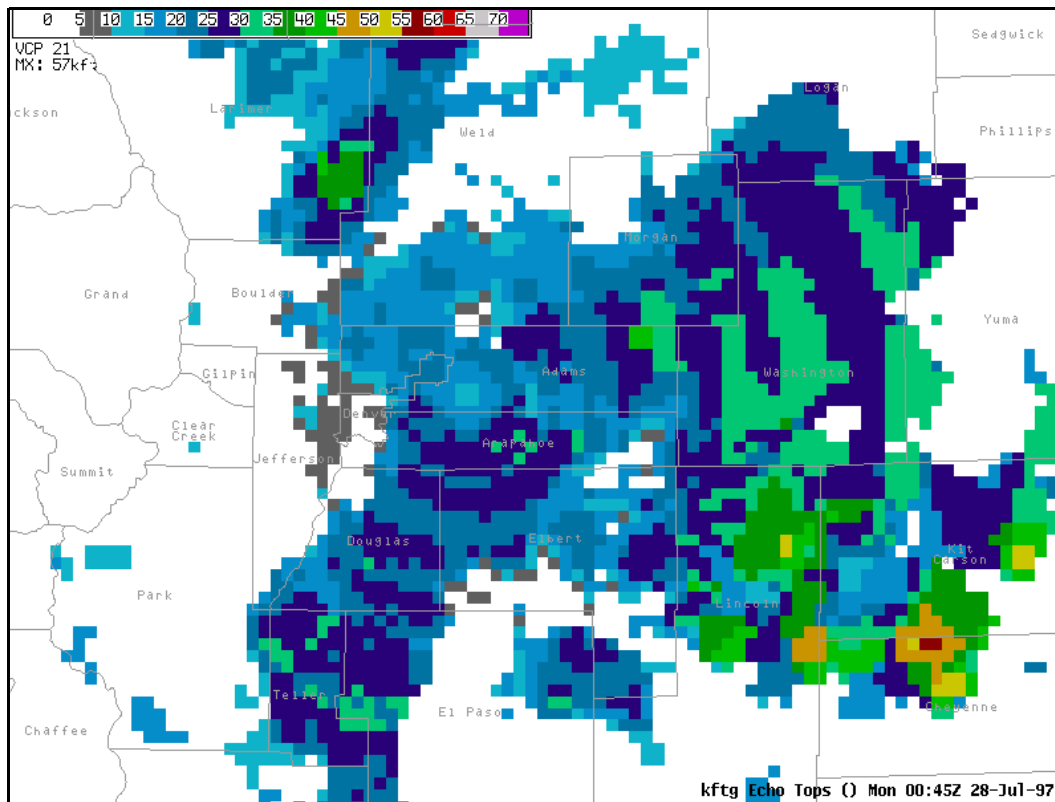


Figure 3-22. Echo Top (ET) product

Echo Tops Product Parameters

Echo tops will vary from cell tops because the SCIT algorithms use the height of the upper most component (ARL). Echo tops uses reflectivities ≥ 18.3 dBZ (MSL) which corresponds to the minimum detectable echo on earlier radars (WSR-57S and WSR-74C).

See Figure 3-22 for an example of the ET product

ET product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Echo Tops
- UNITS: kft
- DATE: Day of week, time, and date in UTC

ET product annotations

- VCP: 11, 21, 31 or 32
- MX: This is the maximum height (kft) on the product, with the location unknown. This value will not change when zoomed in on a feature, as it is the max value for the entire product.

Additional ET product characteristics:

- RANGE: 124 nm
- RESOLUTION: 2.2 x 2.2 nm
- DATA LEVELS: 16 Data levels - values range from 5 kft to 70 kft

1. **A circular stair-stepped appearance will often be evident** due to use of beam center-line.
2. No upward extrapolation from the last elevation angle where precipitation was detected.
3. Side lobes may result in overestimated tops.
4. Tops will be underestimated close to the radar due to the cone of silence.
5. Difficult to locate the highest echo top in a storm due to lack of upward vertical extrapolation, and heights are displayed in 5000 ft increments. (See Fig. 3-23 on page 66.)

Echo Top Limitations

1. **Quick estimation of the most intense convection**; higher echo tops.
2. Assist in differentiating non-precipitation echoes from real storms.
3. Aids in identification of storm structure features such as tilt, updraft flank, max top over strong low level reflectivity gradient, etc.
4. May detect mid-level echoes before low-level echoes are detected.

Echo Tops Strengths/ Applications

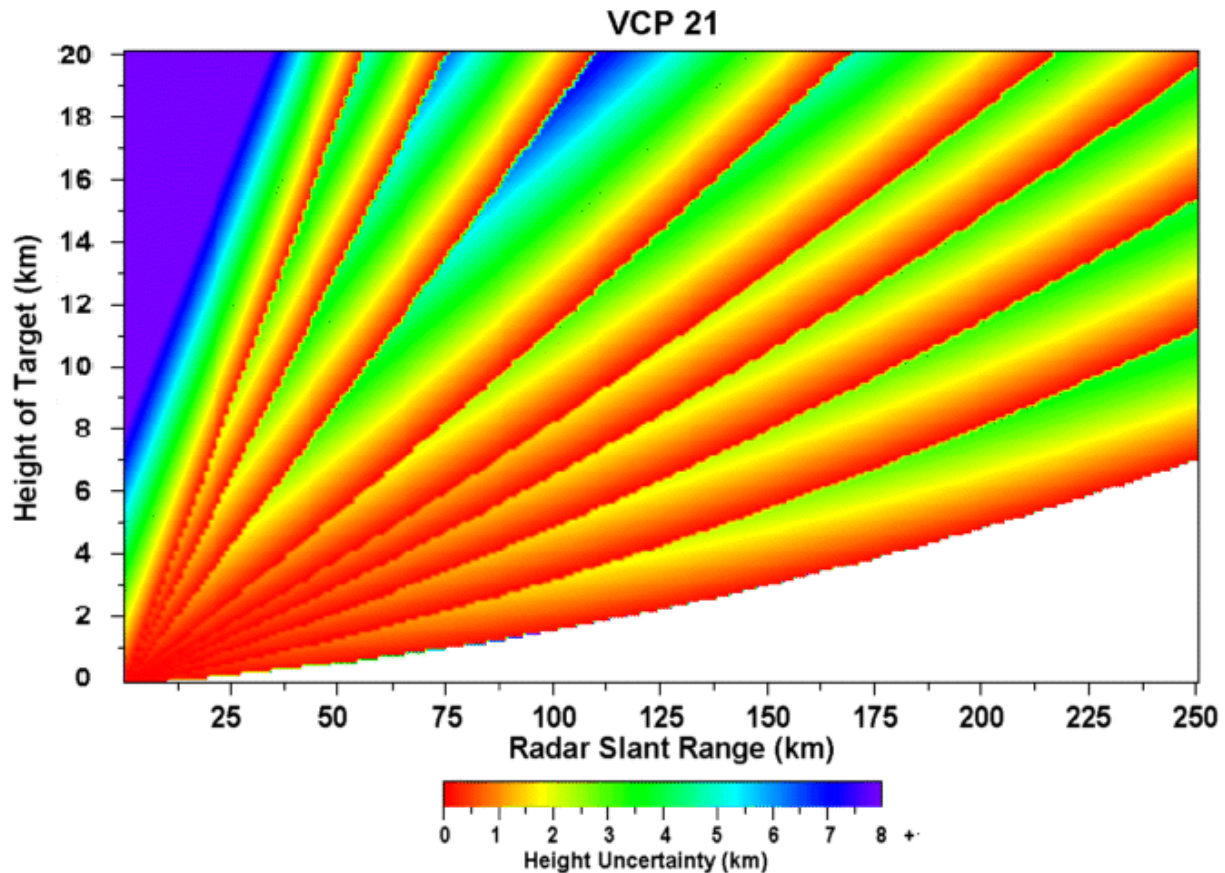


Figure 3-23. Height uncertainty as related to elevation angle.

Echo Tops Contour (ETC)

Echo top data displayed as a line contour image (MSL).

Minimum contour interval of 2,000 ft with a default contour interval of 5,000 ft

First contour is adaptable at the ORPG HCI with a default value of 20,000 ft.

Only resolution 2.2 x 2.2 nm; Range 124 nm

This is the same contouring algorithm used for the other contour products. Once the data is smoothed, contouring begins at the lowest con-

touring value to be drawn and works its way up in value.

The ETC is more difficult to interpret, so it will be less useful in storm structure evaluation.

1. Interpretation difficult
2. Non-precipitation echoes may contaminate product
3. Contour lines may just end or higher values may not be available if product gets too big
4. Contour products may produce loadshedding

See also: Echo Top Limitations on page 65.

1. Estimate most intense convection for aviation briefings

Echo Top Contour Limitations

Echo Top Contour Strength/ Application

Interim Summary

Echo Tops Product

1. Measures height of ≥ 18.3 dBZ echo; height in MSL using the beam center point altitude.
2. Primary use of product is to identify storms with greater vertical development.
3. Aid in differentiating real echoes from non-precipitation echoes.

Echo Tops Contour Product

1. A line contoured image of the Echo Tops product.
2. Difficult to interpret.

Lesson 4: Velocity Based Algorithms and Products

Velocity Derived Products are those which use the Base Velocity Data as their primary input. The benefit of these algorithms is that they quickly analyze the entire volume scan of velocity data and give the operator guidance as to which areas need additional investigation. Keep in mind that the Base Velocity Data used in these algorithms has already undergone dealiasing as well as range-unfolding before being ingested. As a result, problems such as dealiasing failures or range folding will occasionally make it more difficult for the Velocity Derived Algorithms to produce accurate information

Overview

The WSR-88D measures only radial velocity.

Review

Actual vs Detected Wind Speed

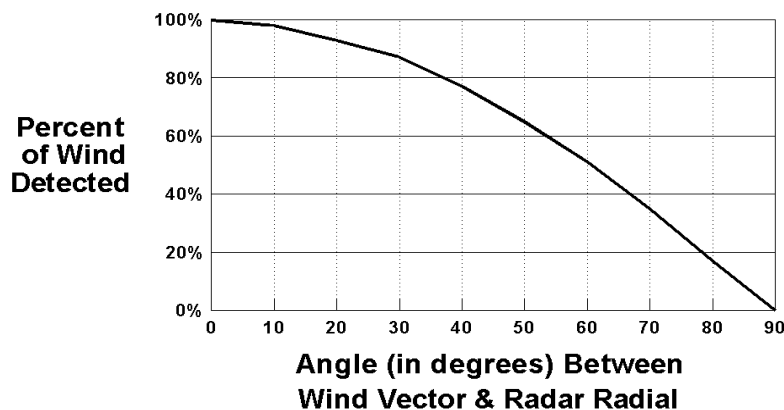


Figure 4-1. If the wind direction is directly down the radial, 100 percent of the velocity will be measured. If it is blowing perpendicular across the radial, 0 percent will be measured. Always keep this in mind when estimating wind speed from Doppler velocities.

Knowledge of where the RDA is in relation to the feature is also very important for proper interpretation. Use of the Polar Grid background map may

help the operator to locate the radar when magnification is done.

Here is a quick review of some small scale signatures and their positions relative to the radar. Notice how the signatures look the same, but because they are in different locations relative to the radar, they would be interpreted differently.

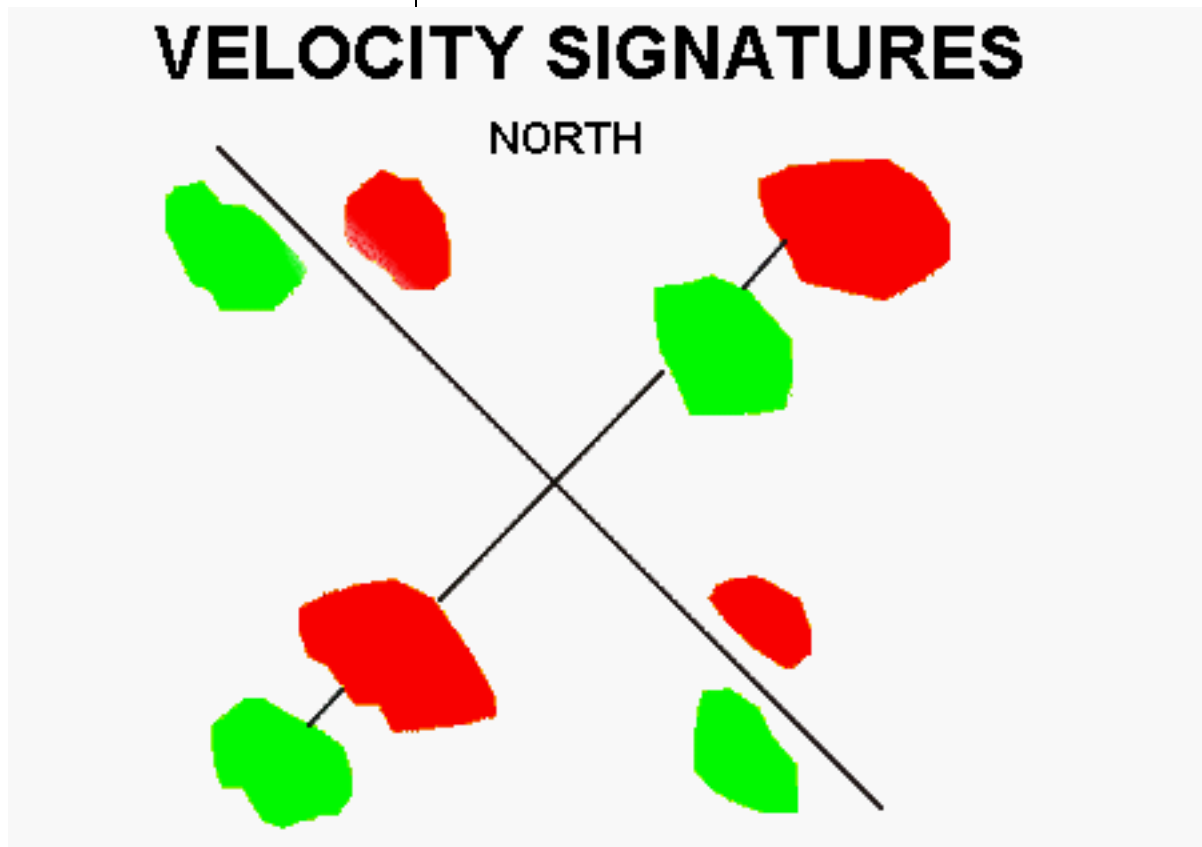


Figure 4-2. Small scale signatures.

Objectives

Without references and according to the lesson, you will be able to identify one strength and one limitation of the following velocity products:

1. Storm Relative Mean Radial Velocity Map (SRM)
2. Storm Relative Mean Radial Velocity Region (SRR)
3. Velocity Cross Section (VCS)

4. Velocity Azimuth Display (VAD)
5. Velocity Azimuth Display Wind Profile (VWP)
6. Mesocyclone (M), and
7. Tornadic Vortex Signature (TVS)

Storm Relative Mean Radial Velocity Map (SRM)

SRM Overview

A long name which will be shortened to SRM from here on out! The SRM is a 124 nm radius product of mean radial velocity with an estimated storm motion subtracted out.

In the example below, the identical mesocyclone is displayed using a Base Velocity product (left) and the SRM Product (right). The storm is moving to the northeast at 40 kts. The Base Velocity is measuring both the circulation and the storm motion. Therefore, all we see is outbound velocities (much stronger on the right side of the couplet). In the SRM, we take away the motion of the storm itself, leaving only the circulation. The couplet is now very apparent to the observer showing the classic signature for pure rotation. Unless you are very experienced, you might not suspect a circulation is present using base velocity alone. However by looking at the SRM, you can now take steps to evaluate the strength of the circulation and determine a course of action.

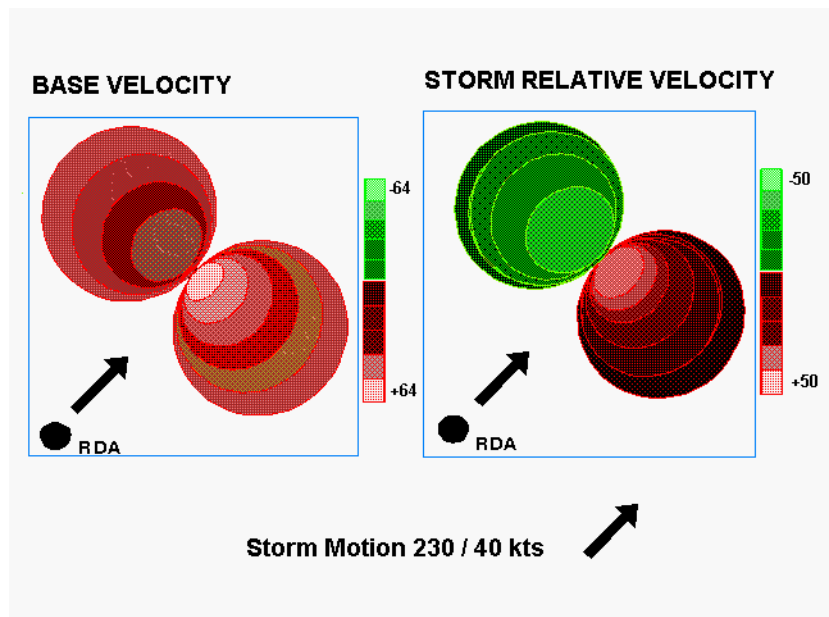


Figure 4-3. When storm motion is subtracted, circulations are easier to see.

Default Storm Motion

Estimated storm speed and direction used by the algorithm will default to the ***average motion of all storms*** from the Storm Track Information Product (from the previous completed volume scan). Keep in mind the limitations of the SCIT algorithm which can cause erroneous storm motions to be generated. If these errors occur, they will be passed along to this algorithm.

Operator Input Storm Motion

To override this, speed and direction can be input by an AWIPS operator on a one-time request basis to an associated RPG. The Repeat Count Function may be used. Only SRMs with the default motion subtracted can be received from Non-associated RPGs.

Dedicated - One Time Request

Repeat count: 1 RPG: KSOX

Product: Storm Rel Velocity (SRM)

Request Interval: 1

Elevation: 0.5

☐ Use vector average of currently identified storms

Speed (kt) 27.0

Direction (deg) 235.0

Time: ☒ Current ☐ Latest ☐ Selected

Selected time: Current

Select time...

Send Close

Figure 4-4. Operator input storm motion of 235° at 27 kts.

Vector subtraction of estimated storm speed and direction is made from every 0.13nm base velocity range gate to a radius of 124nm. The SRM displays the **maximum** value of every four 0.13nm range bins in each 0.54nm range gate. Recall that Base Velocity uses the **first** of every four 0.13nm range bins. This means that velocities will appear slightly stronger on the SRM than for the same range bin on the Base Velocity. This characteristic will sometimes make it beneficial to use an SRM in light wind flow situations to locate residual outflow boundaries.

SRM vs. Base Velocity

Base Velocity vs SRM

Values assigned to .54 nm range bins

Four 1° X .13 nm range bins

18	20	22	19
----	----	----	----

Velocity values for each of the four .13 nm range bins

One 1° X .54 nm range bin

18

Base Velocity encodes the **FIRST** of each of the four bins.

One 1° X .54 nm range bin

22

Storm Relative Velocity encodes the **MAXIMUM** of four bins.

Figure 4-5. Base Velocity vs. SRM value. (Storm motion is 0/0 in this example.)

- Product Uses**
- SRM is useful in detecting shear regions
- 1) Mesocyclone
 - 2) TVS
 - 3) Upper level divergence

***What feature are you attempting to see?** When using Storm Relative products you should always consider your frame of reference. If you are interested in the rotation within a storm, use Storm Relative products. If you are interested in ground relative winds, (i.e., winds associated with a gust front) use the base velocity products.

- Product Description**
- SRM product legend description:
- RPG ID: kxxx
 - ELEVATION ANGLE: in degrees (any one in current VCP)
 - PRODUCT NAME: Storm Rel Vel - Map
 - UNITS: kts (nautical miles per hour)
 - DATE: Day of week, time, and date **in UTC**

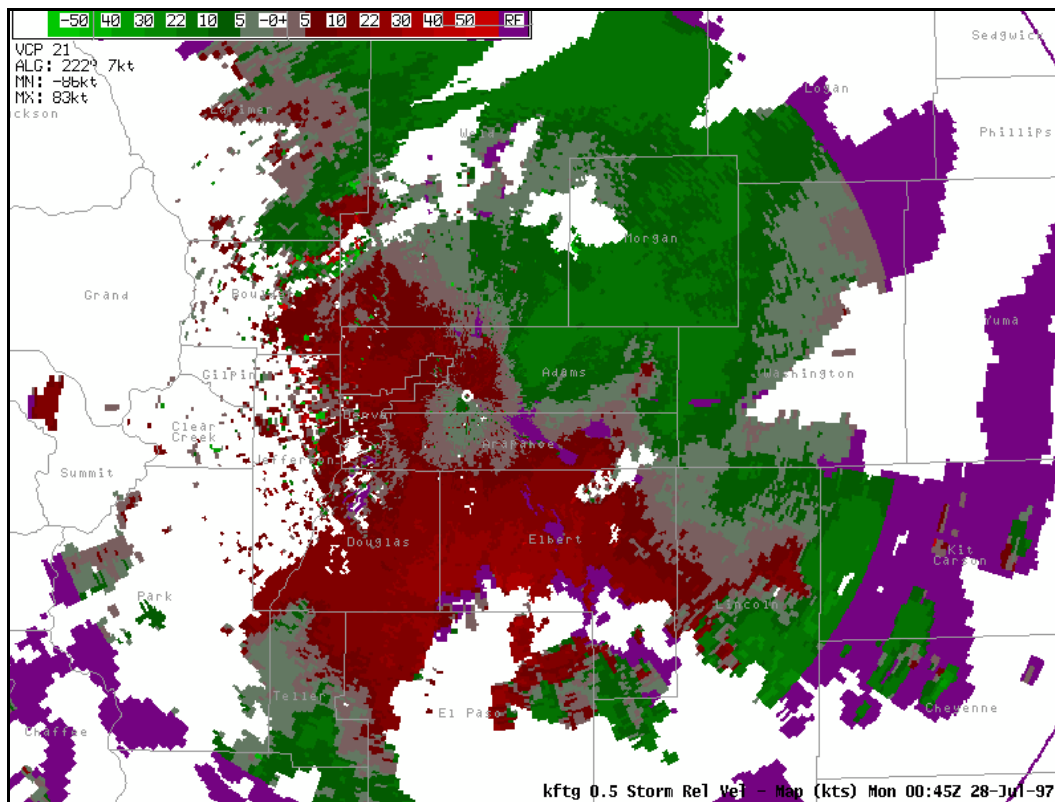


Figure 4-6. Storm Relative Mean Radial Velocity Map (SRM) product

SRM product annotations:

- VCP: VCP 11, 21, 31 or 32
- ALG: This is the default storm motion which has been subtracted out (average of all identified cells). The direction in degrees and speed in kts.
- USR: This is the user supplied storm motion which has been subtracted out. The direction in degrees and speed in kts.
- MN: This is the strongest inbound (negative) velocity detected on the product. The location of this value is unknown, and this is a Storm Relative value.
- MX: This is the strongest outbound (positive) velocity detected on the product. The location of this value is unknown, and this is a Storm Relative value.

Additional SRM product characteristics

- RANGE: 124 nm
- DATA LEVELS:
 - Comes only in 16 data levels from -50 kts to +50 kts, with one level (usually purple or white) for range folded data.
 - Note when comparing Base Velocity and SRM winds, the SRM winds will seem more intense if the same color table is used, since data levels differ.
 - Data levels cannot be changed on the SRM.
 - Data levels are **lower bound**. (For example, 22 kt data level can range from 22-29 kts.)

To investigate a storm three-dimensionally, it is recommended that you put at least 4 elevation cuts on your RPS List to be viewed in a 4-panel presentation or all tilts mode. The slices you choose should be the same as those selected for Base Reflectivity products on your RPS List. The angles you choose will of course depend on the vertical extent of the storm as well as the range to the storm. However, it is always advisable to have a 0.5° Base Velocity on the RPS list to determine ground-relative winds.

SRM Limitations

1. Storm Relative flow will be inaccurate if the storm motion subtracted isn't representative of the storm being investigated.
2. More difficult to determine actual ground-relative winds.
3. Average Storm Relative motion likely will vary from volume scan to volume scan. SCIT computes the average storm motion each volume scan, so strong rotation on one scan may not

be as obvious on the next scan. This could really be due to a change in the average storm motion used as input, rather than the storm actually changing.

4. Data levels differ from Base Velocity product
1. Used to investigate the 3-D velocity structure of a storm when used in a 4 panel
2. Most useful with faster moving storms (> 10 kts)
3. Operator may input storm motion at AWIPS.
4. Input a "ZERO" storm motion will output max velocities for 0.54 **resolution velocity product**. This is one way to get the max value for every 4 gates unlike Base Velocity products which show the 1st of every 4.

SRM Strengths/ Applications

Storm Relative Mean Radial Velocity Region (SRR)

The SRR is very similar to the SRM product only it is considered a "window" product. The SRR is generated for a small (approximately 38nm radial length) window of the radar coverage area centered on a user defined point (usually a storm of interest).

The motion subtracted from the product defaults to the storm closest to the product center. If no storm is within the product window, then the storm motion subtracted defaults to the average of all storms. If no storms are identified then the default is the default storm speed/direction set at the ORPG HCI.

SRR Overview

Dedicated - One Time Request

Repeat count: 1 RPG: KABR

Product: Storm Rel Vel Region (SRR)

Priority: Low

Request Interval: 1

Elevation: 0.5

Point: A Azimuth: 54° Range: 62.4777 nMi Load Points

☐ Use storm closest to window center

Speed (kt) 25.1

Direction (deg) 241.5

Time: ☒ Current ☐ Latest ☐ Selected

Selected time: Current Change...

Send Close

Figure 4-7. SRR product request screen.

Just as with the SRM, the user can choose to override the algorithm generated motion and supply an operator defined motion if the default motion is in question.

The SRR has twice the resolution of the SRM (.27 nm instead of .54 nm). Similar to the SRM, the SRR displays the maximum of every two 0.13 nm range bins.

SRR Product Parameters

The SRR product legend description:

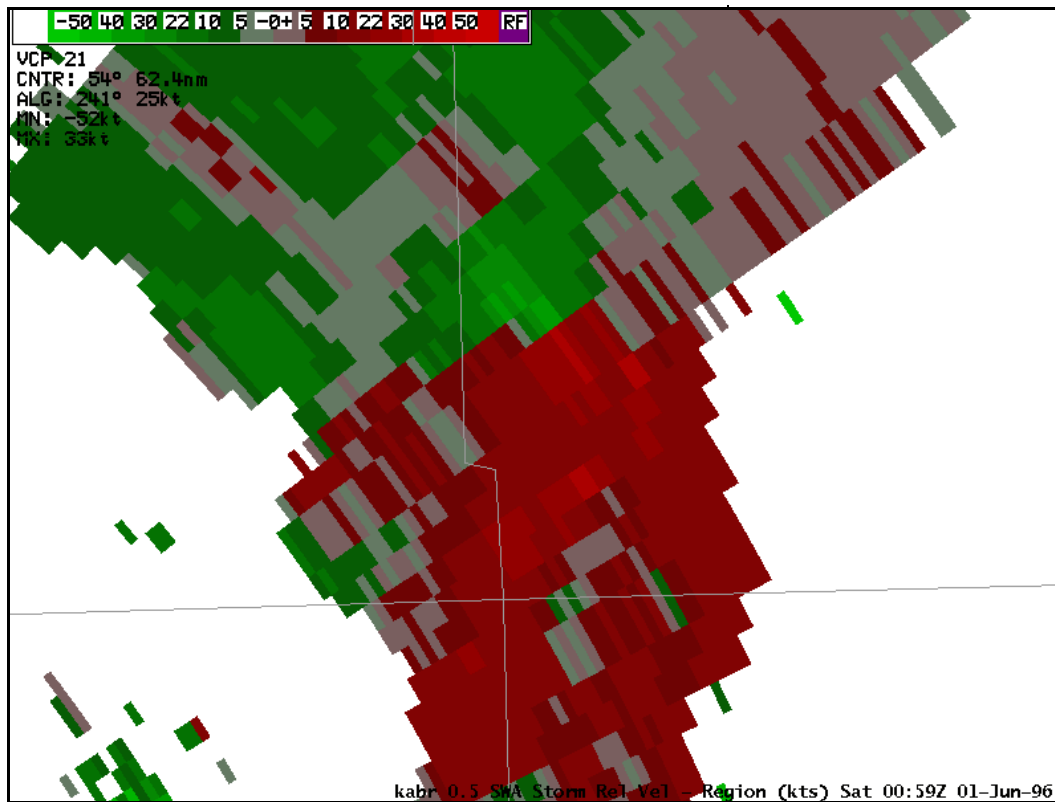


Figure 4-8. Storm Relative Mean Radial Velocity Region (SRR) product.

- RPG ID: kxxx
- ELEVATION ANGLE: in degrees (any one in current VCP)
- PRODUCT NAME: Storm Rel Vel - Region
- UNITS: kts (nautical miles per hour)
- DATE: Day of week, time and date in **UTC**

SRR product annotations:

- VCP: VCP 11, 21, 31, or 32
- ALG: This is the default storm motion (motion of cell nearest product center)
- USR: This is the user supplied storm motion
- MN: This is the strongest inbound (negative) velocity detected in the window. The location of this value is unknown, and this is a Storm Relative value.

- MX: This is the strongest outbound (positive) velocity detected in the window. The location of this value is unknown, and this a Storm Relative value.

Additional SRR product characteristics

- COVERAGE: approximately 38 nm radial length
- RESOLUTION: 0.27 nm
- CNTR - location of AZRAN selected (product center point)

RPS List

The SRR is a valuable product, however it is NOT recommended for the RPS list. Since the product coverage is a small area, the storm of interest will likely move out of the window in a few volume scans. It is therefore better to get this product via a one-time request (using repeat count if desired for a few volume scans).

SRR Limitations

1. Storm relative flow will be inaccurate if storm motion used isn't representative of storm being investigated.
2. Difficult to determine ground-relative winds. Use Base Velocity products to determine ground-relative winds.
3. Limited viewing area.
4. Data levels differ from Base Velocity product.

SRR Strengths/ Applications

1. ***Better resolution and less chance for Storm Relative error than on SRM product.*** The resolution of the SRR is .27 nm and uses only one storm motion as default, versus .54 nm resolution and the average of all storms with SRM.
2. Aids in displaying: shear and rotation in storms, and storm top divergence.

3. Operator may input storm motion at the AWIPS workstation.
4. Displayed max inbound/outbound velocities are valid within window.
5. Can obtain a .27 nm resolution storm relative velocity product anywhere within 124 nm of the radar.

Velocity Cross Section (VCS)

VCS Overview

The Velocity Cross Section is a cross section of the Base Velocity data. This product is produced in a similar manner as the Reflectivity Cross Section (RCS). ***Interpolation*** is used to fill data gaps. Although the horizontal resolution of the product is 0.54nm, the VCS uses the maximum value of every four 0.13nm range bins. Therefore, values displayed on the VCS may appear higher than on the 0.54nm Base Velocity products.

As with RCS, the two points picked must be within 124 nm of the RDA and no more than 124 nm apart.

Since radial base velocity data is used to produce the VCS, it is strongly suggested that the VCS be generated using two points either:

- ***along a radial*** to see convergent/divergent signatures and/or updraft/downdraft interface
- ***over a short distance perpendicular to the radial*** to see rotation.

Useful product, but not recommended for RPS list - Use this as a supplemental product, particularly in a research mode.

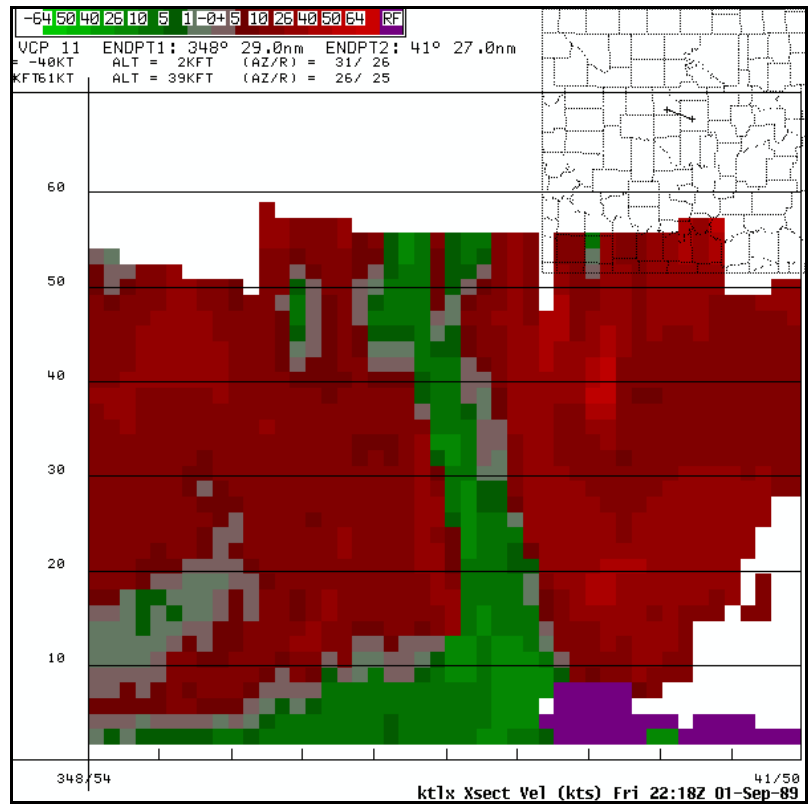


Figure 4-9. Velocity Cross Section (VCS) product. Note geographic location in upper right corner.

VCS Adaptable Parameters (at the ORPG HCI or UCP)

VCS Product Characteristics

If the user changes the velocity data levels for the Base Velocity products *at the ORPG HCI or UCP*, this will also change the data levels for the VCS.

The Velocity Cross Section has the following characteristics:

- RESOLUTION: 0.54 nm horizontal res X 0.27 nm vertical res.
- COVERAGE: 124nm X 70,000 ft
- DATA LEVELS: 8 or 16 data levels
- Height on Z axis in 10,000 ft intervals.
- Range on x/y axis depends upon length of cross section (the endpoints are in km).
- Left side of product is western most point chosen (ENDPT1), unless along the same longi-

tude, then the northern point will be on the left side (ENDPT2).

See Fig. 4-9 for an example of the VCS Product

VCS Product Parameters

VCS product legend description

- RPG ID: kxxx
- PRODUCT NAME: Xsect Vel
- UNITS: kts
- DATE: Day of week, time, and date in UTC

VCS product annotations

- VCP: 11, 21, 31, or 32
- ENDPT 1: AZRAN of the western-most point (nm)
- ENDPT 2: AZRAN of the eastern-most point (nm)
- MIN (inbound) velocity, ALTitude (ARL in kft), AZ/R (AZRAN in degrees and nm)
- MAX (outbound) velocity, ALTitude (ARL in kft), AZ/R (AZRAN in degrees and nm)

1. ***Doppler velocities are relative to the RDA.***

As stressed in Velocity Interpretation, you must always know where the phenomenon is in relation to the RDA. This increases the importance of baseline map in the upper right of the cross section.

2. ***Height exaggerated versus range*** (70,000 ft vs. up to 124 nm range). This is the same limitation observed in the RCS product. Features are not to scale, and appear thinner and taller than they actually are.

3. ***Interpolation may enlarge or miss features.***

Just as with the RCS product, gaps in the VCP will result in interpolations which may smooth

VCS Limitations

out or enlarge a particular feature (especially in VCP 21).

4. ***Storm Relative cross section is NOT available. This may make it difficult to interpret signatures in especially fast moving storms.***
5. ***Storm top divergence estimates are limited due to radar viewing angle and data thresholds.*** Difficult to determine hail larger than golf ball size using NSSL criteria unless both maxima listed on the top of the grid are close to the the storm summit.

* Remember, a VCS perpendicular to the radial can be used to see rotation, while a VCS along a radial can be used to see convergence/divergence. However, the ability to see features with the cross section products is highly dependent upon placement of the cross section. A 4-panel velocity or SRM (or use all of the tilts) will probably get better results.

VCS Strengths/ Applications

1. Aid in determining storm structure features such as:
 - Inferring location of updrafts/downdrafts
 - Strength of storm top divergence
 - Depth of mesocyclones
2. Has proven very valuable for kinematic insights in a research setting.

Interim Summary

1. Storm motion subtracted from Base Velocity data.
2. Storm motion defaults to average motion of all storms from Storm Track algorithm, but operator may input motion.
3. Aid in determining shear regions and storm top divergence which may be obscured by storm motion.
4. Especially useful with faster moving storms.

Storm Relative Mean Radial Velocity Map

1. Storm motion subtracted from Base Velocity data for a small geographical area.
2. Storm motion defaults to identified storm within a small window; resolution is .27 nm.
3. Aid in detecting shear regions and storm top divergence.
4. Especially useful with faster moving storms.

Storm Relative Mean Radial Velocity Region

1. Vertical cross section of the Base Velocity data.
2. Should be generated either along a radial to see convergent or divergent signatures, or over short distances perpendicular to a radial to see rotation.
3. Aid in inferring updraft/downdraft interface locations, storm top divergence and the depth of mesocyclones.

Velocity Cross Section

Velocity Azimuth Display (VAD)

VAD Overview

Although the VAD product is not a commonly used product, the VAD winds are output to two important places -- the VAD Wind Profile (VWP) Product and the Environmental Winds Table. Therefore, an understanding of the VAD Algorithm and VAD product is important.

You have used the Base Velocity products and attempted to infer wind speed and direction at a particular height (range) by using the zero isodop. The VAD algorithm attempts to do this at several heights. The VAD Product is a scattering of data points used to compute the wind speed and direction for a given height. Although only radial velocity (inbound or outbound) is measured at a given point, the radial velocities 360 degrees around the radar at a given height (range) can produce an estimate of the average wind speed, and actual wind direction (i.e., the azimuth of the strongest inbound wind approximates the direction the wind is coming from).

Algorithm Methodology

Slant Range

1. The VAD winds are computed using a single elevation angle at a constant **slant range**. For each altitude requested on the VAD Wind Profile, the VAD Algorithm selects the elevation angle that is closest to intersecting that altitude at the **VAD range** (adaptable parameter with a default of 30 km or 16.2 nm). The actual slant range will change dependent upon the altitude for which the VAD wind is being calculated (See Fig. 4-10 on page 87.).

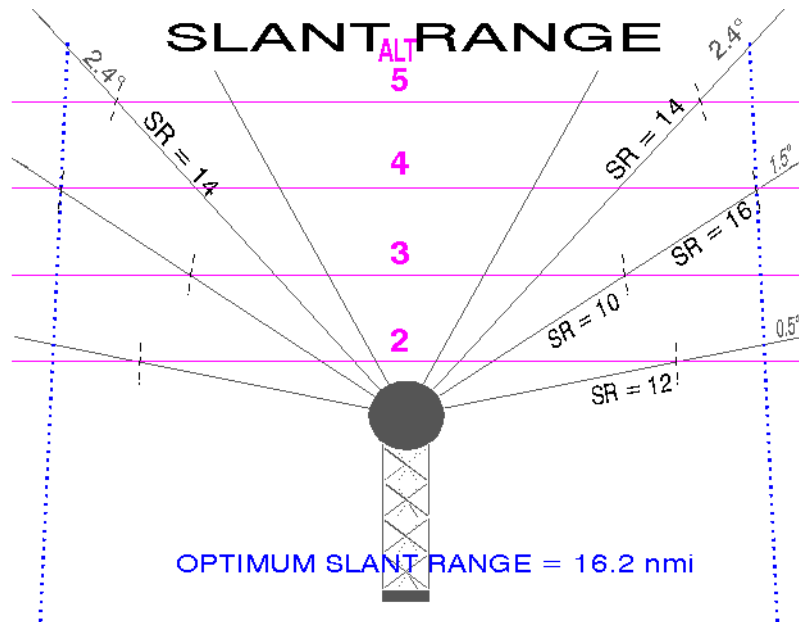


Figure 4-10. Slant Range

2. A **0.13 nm resolution base velocity data point** is plotted on a graph at each azimuth.

The x-axis on the graph is azimuth ($0^\circ/360^\circ$ for N, 180° for S of the RDA), and the z-axis is velocity (positive outbound velocities at the top and negative inbound velocities at the bottom).

3. If there are **25 data points** plotted on the graph, the algorithm then computes a **sine wave** to fit to the data (using least squares fit method). The VAD wind is computed from this sine wave. The amplitude of the sine wave is the estimated wind speed. The strongest inbound portion of the sine wave (closest to the bottom of the graph) becomes the estimated wind direction.

Velocity Data Plotted

Sine Wave Fit to the Data

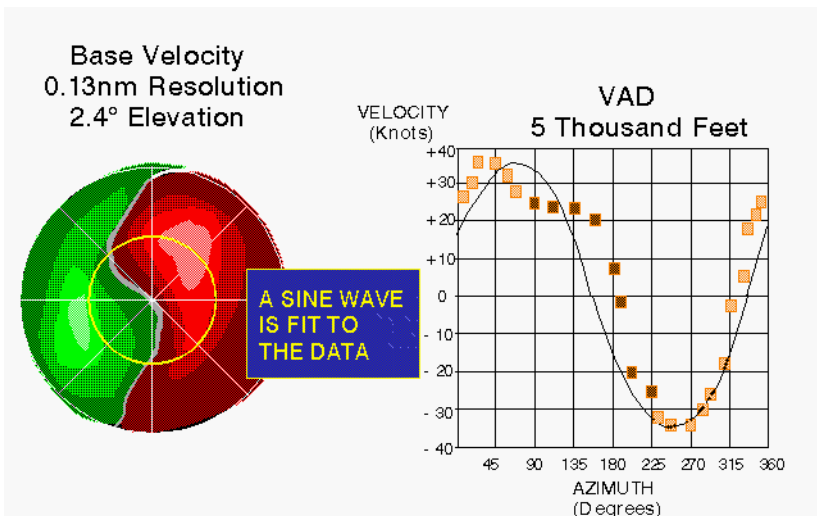


Figure 4-11. VAD data fit.

Symmetry and RMS error

4. Two additional values are calculated -- **Symmetry and RMS error**. **Symmetry** is the difference in knots between the zero velocity line on the VAD coordinate system and the median line of the sine wave curve. If the symmetry is negative (median line below the zero line) the inbound winds are stronger than the outbound indicating convergent flow at the radar site. Positive symmetry indicates diverging wind. **RMS error** (Root Mean Square error) is a calculation of the variation of the winds from the plotted sine wave. **RMS error can be used as an indicator of the reliability of the wind estimate.**

If the symmetry exceeds 13.6 kts, or the RMS error exceeds 9.7 kts (ROC adaptable parameters), the winds can be determined by the operator using the plotted sine wave, but will not be output to the VAD Wind Profile (VWP) product.

VAD Altitudes

The VAD is available only for heights requested on VAD Wind Profile (VWP). These heights are determined by the user at the VAD and RCM Height Selection screen **at the ORPG HCI** (URC adaptable). See Figure 4-12.

IC 5.5 WSR-88D Derived Products

Close

Save

Undo

Baseline:

Restore

Update

☐ Contour Product
 ☐ Cell Product
 ☐ Layer Product

Category:

☐ OHP/THP Data Levels
 ☐ RCM Product
 ☐ RCM Reflectivity Data Levels

☐ STP Data Levels
 ☒ VAD and RCM Heights
 ☐ Velocity Data Levels

VAD and RCM Height Selections

Level	VAD	RCM	Level	VAD	RCM	Level	VAD	RCM	Level	VAD	RCM	Level	VAD	RCM	Level	VAD	RCM	Level	VAD	RCM
1	<input type="checkbox"/>	<input type="checkbox"/>	11	<input checked="" type="checkbox"/>	<input type="checkbox"/>	21	<input type="checkbox"/>	<input type="checkbox"/>	31	<input type="checkbox"/>	<input type="checkbox"/>	41	<input type="checkbox"/>	<input type="checkbox"/>	51	<input type="checkbox"/>	<input type="checkbox"/>	61	<input type="checkbox"/>	<input type="checkbox"/>
2	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	12	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	22	<input checked="" type="checkbox"/>	<input type="checkbox"/>	32	<input type="checkbox"/>	<input type="checkbox"/>	42	<input type="checkbox"/>	<input type="checkbox"/>	52	<input type="checkbox"/>	<input type="checkbox"/>	62	<input type="checkbox"/>	<input type="checkbox"/>
3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	13	<input checked="" type="checkbox"/>	<input type="checkbox"/>	23	<input type="checkbox"/>	<input type="checkbox"/>	33	<input type="checkbox"/>	<input type="checkbox"/>	43	<input type="checkbox"/>	<input type="checkbox"/>	53	<input type="checkbox"/>	<input type="checkbox"/>	63	<input type="checkbox"/>	<input type="checkbox"/>
4	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	14	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	24	<input checked="" type="checkbox"/>	<input type="checkbox"/>	34	<input type="checkbox"/>	<input type="checkbox"/>	44	<input type="checkbox"/>	<input type="checkbox"/>	54	<input type="checkbox"/>	<input type="checkbox"/>	64	<input type="checkbox"/>	<input type="checkbox"/>
5	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	15	<input checked="" type="checkbox"/>	<input type="checkbox"/>	25	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	35	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	45	<input checked="" type="checkbox"/>	<input type="checkbox"/>	55	<input type="checkbox"/>	<input type="checkbox"/>	65	<input type="checkbox"/>	<input type="checkbox"/>
6	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	16	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	26	<input checked="" type="checkbox"/>	<input type="checkbox"/>	36	<input type="checkbox"/>	<input type="checkbox"/>	46	<input type="checkbox"/>	<input type="checkbox"/>	56	<input type="checkbox"/>	<input type="checkbox"/>	66	<input type="checkbox"/>	<input type="checkbox"/>
7	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	17	<input checked="" type="checkbox"/>	<input type="checkbox"/>	27	<input type="checkbox"/>	<input type="checkbox"/>	37	<input type="checkbox"/>	<input type="checkbox"/>	47	<input type="checkbox"/>	<input type="checkbox"/>	57	<input type="checkbox"/>	<input type="checkbox"/>	67	<input type="checkbox"/>	<input type="checkbox"/>
8	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	18	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	28	<input checked="" type="checkbox"/>	<input type="checkbox"/>	38	<input type="checkbox"/>	<input type="checkbox"/>	48	<input type="checkbox"/>	<input type="checkbox"/>	58	<input type="checkbox"/>	<input type="checkbox"/>	68	<input type="checkbox"/>	<input type="checkbox"/>
9	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	19	<input checked="" type="checkbox"/>	<input type="checkbox"/>	29	<input type="checkbox"/>	<input type="checkbox"/>	39	<input type="checkbox"/>	<input type="checkbox"/>	49	<input type="checkbox"/>	<input type="checkbox"/>	59	<input type="checkbox"/>	<input type="checkbox"/>	69	<input type="checkbox"/>	<input type="checkbox"/>
10	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	20	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	30	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	40	<input checked="" type="checkbox"/>	<input type="checkbox"/>	50	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	60	<input type="checkbox"/>	<input type="checkbox"/>	70	<input type="checkbox"/>	<input type="checkbox"/>

Height levels are represented in Kft.

NOTE: Up to 30 VAD height levels may be selected. Up to 19 RCM height levels may be chosen. An RCM level must be paired with a VAD height level.

Figure 4-12. VAD Height Selection screen at the ORPG HCI.

VAD winds are also output to the Environmental Winds Table used in the Velocity Dealiasing Algorithm. If the VAD winds are bad, the ORPG HCI operator can turn off Auto Update, and manually input winds from a raob or profiler. See Figure 4-13.

Output to the Environmental Winds Table

The 'Environmental Data Entry' window contains the following sections:

- Buttons:** Close, Save, Undo, Clear
- Environmental Winds Data:**
 - Coded Msg (PPBB): [Text Field]
 - ☒ Interpolate between levels
 - Table with columns: Lvl (kft), Dir (deg), Spd (kts)
- Hail Temperature Heights:**
 - Last Update: 01/01/96 - 12:00:00
 - Height -20 C (0-70 kft MSL): [20.0]
 - Height 0 C (0-70 kft MSL): [10.5]
- Default Storm Motion:**
 - Direction (0-360 deg): [225]
 - Speed (0-99.9 kts): [25.0]

Lvl kft	Dir deg	Spd kts
1.3	120	15.0
2.3	140	22.0
3.3	150	25.0
4.3	170	30.0
5.3	181	33.9
6.3	189	38.7
7.3	195	44.2
8.3	200	50.0
9.3	213	47.2
10.3	226	46.9
11.3	239	49.2
12.3	251	53.7
13.3	260	60.0
14.3	266	67.2
15.3	270	75.0
16.3		

Figure 4-13. Environmental Winds Edit screen at the ORPG HCI.

VAD Adaptable Parameters

There are three VAD adaptable parameters of importance: range, beginning azimuth and ending azimuth. They are edited at *the ORPG HCI*. See Figure 4-14.

The 'Algorithms' window displays the 'Adaptation Item' as VAD. Below is a table of parameters:

Name	Value	Range
RMS Threshold [THV]	5.0	0.0 <= x <= 15.0, m/s
Number Of Passes [FT]	2	1 <= x <= 5
Data Points Threshold [NPTS]	25	1 <= x <= 360
VAD Analysis Slant Range [VAD]	30.0	1.0 <= x <= 230.0, km
Beginning Azimuth Angle [TEZ]	0.0	0.0 <= x <= 359.9, degrees
Ending Azimuth Angle [TEZ]	0.0	0.0 <= x <= 359.9, degrees
Symmetry Threshold [THY]	7.0	0.0 <= x <= 20.0, m/s

Figure 4-14. VAD Adaptable Parameters edit screen at the ORPG HCI.

The VAD can be put on the RPS list or is available as a one-time request. The parameter that must be selected is the height in kft. See Figure 4-15.

The screenshot shows a dialog box titled "Dedicated - One Time Request". It contains the following fields and controls:

- Repeat count:** A numeric input field set to "1".
- RPG:** A dropdown menu set to "KABR".
- Product:** A dropdown menu set to "Vel Az Display (VAD)".
- Priority:** A dropdown menu set to "Low".
- Request Interval:** A numeric input field set to "1".
- Altitude (kft):** A numeric input field set to "2".
- Time:** Three radio buttons labeled "Current", "Latest", and "Selected". The "Latest" radio button is selected.
- Selected time:** A text input field containing "Latest" and a "Change..." button.
- Buttons:** "Send" and "Close" buttons at the bottom.

Figure 4-15. VAD product request screen.

See Figure 4-16 for an example of the VAD product

VAD Product Parameters

VAD product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Velocity Azimuth Disp
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

VAD Product Annotations

- VCP: 11, 21, 31 or 32
- ALT: Height in kft
- ELEV: Elevation angle that intersects selected height at the VAD range
- RNG: VAD Range
- WND: Wind direction and speed
- RMS: Root Mean Square error

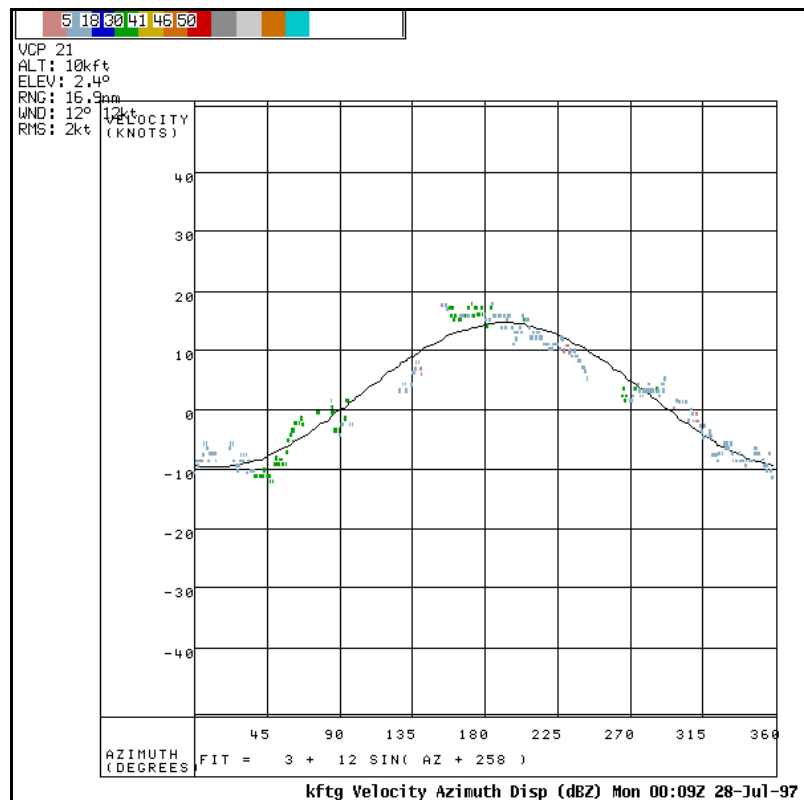


Figure 4-16. Velocity Azimuth Display (VAD) product.

VAD Limitations

1. **Needs sufficient data points** - Clear, cold, dry air often lacks scatterers. No sine wave will be plotted unless there are at least 25 data points.
2. **May be unreliable in disturbed environments** - The algorithm assumes horizontal uniformity of the wind field. If there is a front or

boundary near the RDA, the data will often fail either RMS or symmetry thresholds.

3. Available for preestablished altitudes only - As designated at the ORPG HCI or UCP for the VAD Wind Profile.

4. Large flocks of migrating birds may produce anomalous wind data. The averaging of the motion of birds in conjunction with the motion of the wind, can lead to erroneous wind data. Birds can cause the speed to be off by several knots and the direction to be off by several degrees. Typical symptoms include an “explosion of reflectivity returns in a “butterfly” pattern centered on the RDA just after sunset.

1. VAD Winds are available in clear air or precipitation mode. Generally speaking, the wind estimates will be slightly better in clear air mode since the radar antenna rotation is slower.

2. The VAD algorithm does not require 360 degrees of data. The algorithm only requires 25 data points (a sample from 25 degrees of azimuth), and they don't have to be contiguous. It is possible to only sample a certain sector to produce the VAD winds. For example you could decide to only sample the area between 135° and 225° to get an estimate of the winds ahead of the front. The “Beginning” and “Ending” azimuth is set at the ORPG HCI (under URC Control).

3. Check missing or suspicious wind data on the VAD Wind Profile (VWP) - This is probably the primary reason many operators choose to look at the VAD Product. When you see “ND” plotted on the VAD Wind Profile, you can request the VAD at that altitude and see what happened: no sine wave could be plotted due to high RMS error (>9.7 kts), convergence or divergence in the wind flow produced a symme-

VAD Strengths/ Applications

try error exceeding limits (>13.6 kts), or too few data points (<25).

4. ***Update Environmental Winds Table. The VAD winds are fed into the Environmental Winds Table for use in the velocity dealiasing algorithm. This helps minimize dealiasing errors.***
5. ***VAD winds included on the Radar Coded Message (RCM).***

VAD Wind Profile (VWP)

VWP Overview

The VAD Wind Profile Product (VWP) is a vertical profile of VAD-derived winds at various levels. Winds are plotted on a grid with the X-axis as time and the Z-axis as height in thousands of feet. As many as 11 profiles (11 volume scans) are plotted with the most recent profile at the far right side of the grid (opposite of the Wind Profiler Network time-height profiles).

Product Characteristics

The VAD Wind Profile (VWP) Product has the following characteristics:

- **Altitudes:** A maximum of 30 altitudes can be displayed each volume scan. The displayed MSL altitudes are selected at the ORPG HCI or UCP. There must be a minimum of 1000 feet between levels. The lowest level selected should be the first altitude above the radar level (i.e., if the radar is at 2212 feet, then the lowest altitude selected should be 3 thousand feet). Altitudes to 70,000 feet can be selected, but winds above 45,000 feet are uncommon.
- **Wind Barbs:** Winds are displayed in the standard convention with the shaft always being the same length:
 - Small open circle - < 4 kts

- 1/2 barb - 4-7 kts
- full barb - 8-12 kts
- flag triangle - 50 kts
- **Data Levels** - The data levels of the VWP represent the RMS error in kts of the VAD winds. Recall that the RMS error is a measure of how well the sampled data points fit the sine curve. The first data level represent RMS errors less than 4 kts, the second data level 4-7 kts, and the third data level 8-11 kts. Higher data levels will not be seen on the VWP since “**ND**” will be displayed if the RMS error exceeds 9.7 kts.
- **ND** - No Data will appear if:
 - there are fewer than 25 data points
 - RMS error greater than 9.7 kts, or
 - symmetry is greater than 13.6 kts

See Figure 4-17 for an example of the VWP product

VWP Product Parameters

VWP product legend description:

- RPG ID: kxxx
- PRODUCT NAME: VAD Wind Profile
- UNITS: RMS kts
- DATE: Day of week, time, and date in UTC

VWP product annotations

- VCP: 11, 21, 31 or 32
- HT(MX): Height of the maximum wind from the most recent volume scan.
- MXWND: Maximum wind direction and speed from the most recent volume scan.

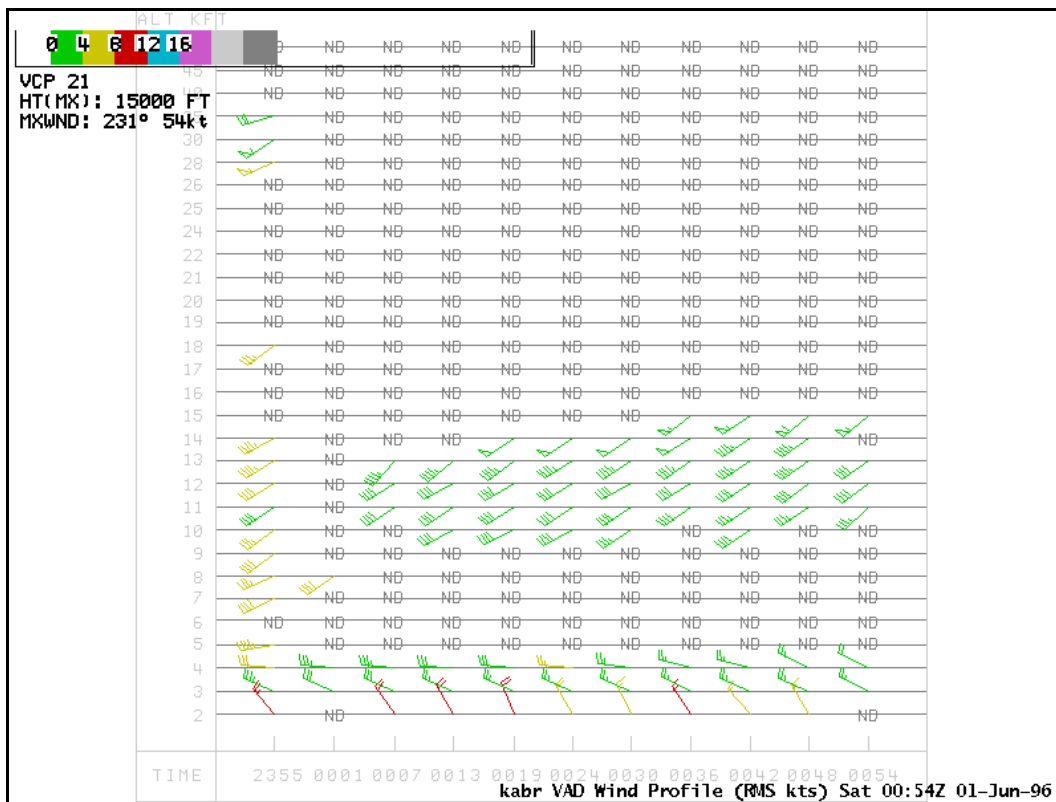


Figure 4-17. VAD Wind Profile (VWP) product.

VWP Adaptation Data

The VWP Adaptation Data can be displayed at the AWIPS Text Display Window (WSRVWPxxx). This can be used to determine the adaptable parameter settings used to generate the product. See Figure 4-18.

VWP Limitations

1. **Measurable returns needed** - at least 25 data points are required on the individual VAD for data to be encoded at that altitude.
2. **Winds are not encoded if RMS error or symmetry thresholds are exceeded.** ND will be plotted if RMS exceeds 9.7 kts or symmetry exceeds 13.6 kts.
3. **Generally only representative of winds within 20 nm of the RDA.**
4. **Difficult to read wind barbs when north wind barbs and south wind barbs are on succes-**

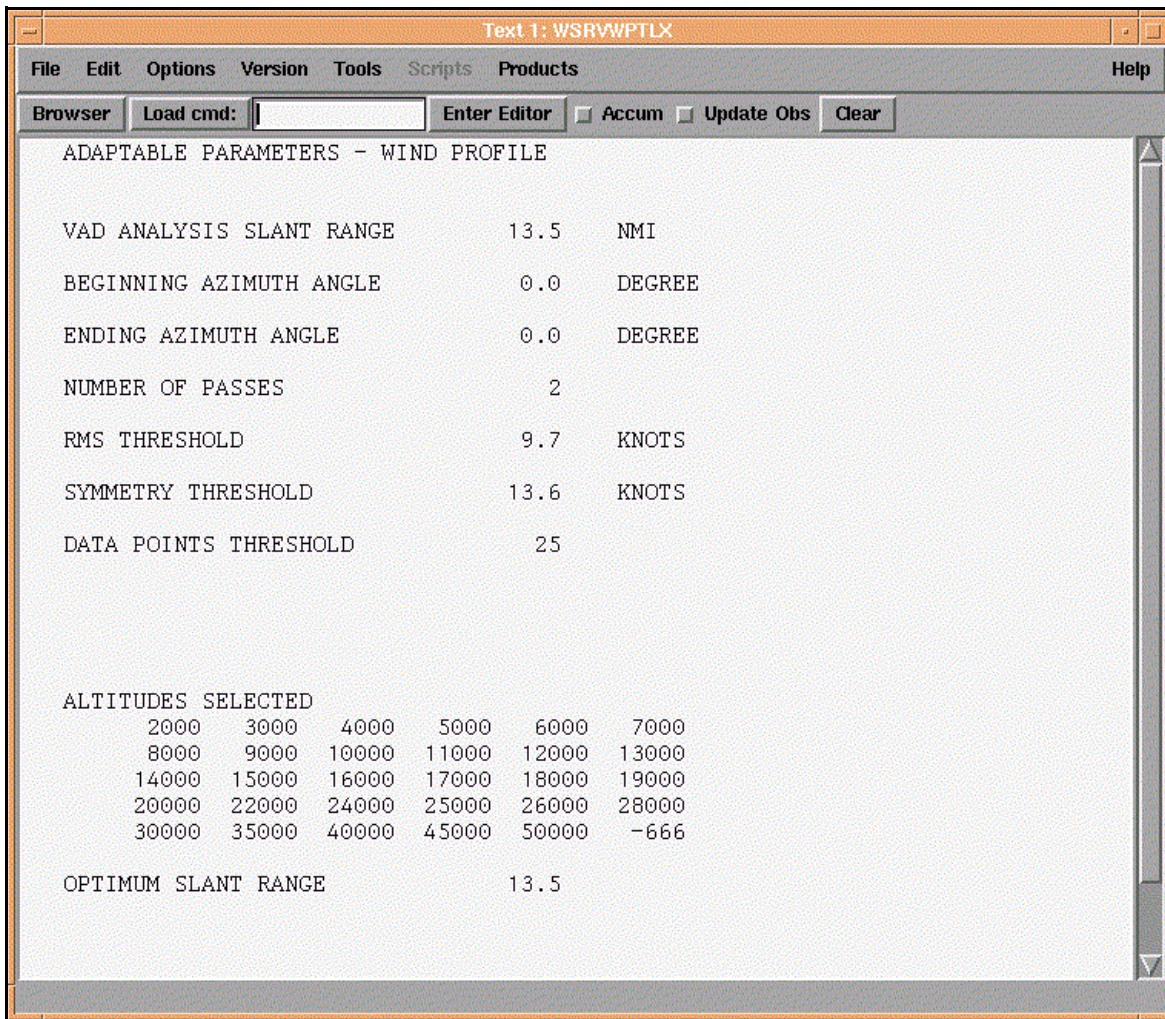


Figure 4-18. VWP adaptable parameters displayed at the AWIPS Text Display Window.

sive altitudes. Use of the Filter or Blink Functions may help.

5. **Birds can produce anomalous wind**

patterns. The usual scenario is an “explosion” of reflectivity coverage and strength as night migrating birds take off. Experts claim that a single Sea Gull can be detected at a range of 460 km. If it is critical to determine the true upper winds, the site should take a supplemental balloon sounding.

1. The VAD Wind Profile (VWP) may be of assistance in many operations. **Severe Weather** operations may benefit as backing or veering of

VWP Strengths/ Applications

the winds with time display changes in the environment. **Aviation** operations will be assisted by evidence of wind shear. Low level wind shear may be more visible on VWP than Profilers. **Hydrology** and **Forecasting** may benefit from indications of the change in the depth of cold air with time, etc. Since sufficient scatterers are often more prevalent in and near clouds, the VWP may be used in estimating cloud tops and bases.

2. ***The VWP can be used to create/adjust hodographs.***

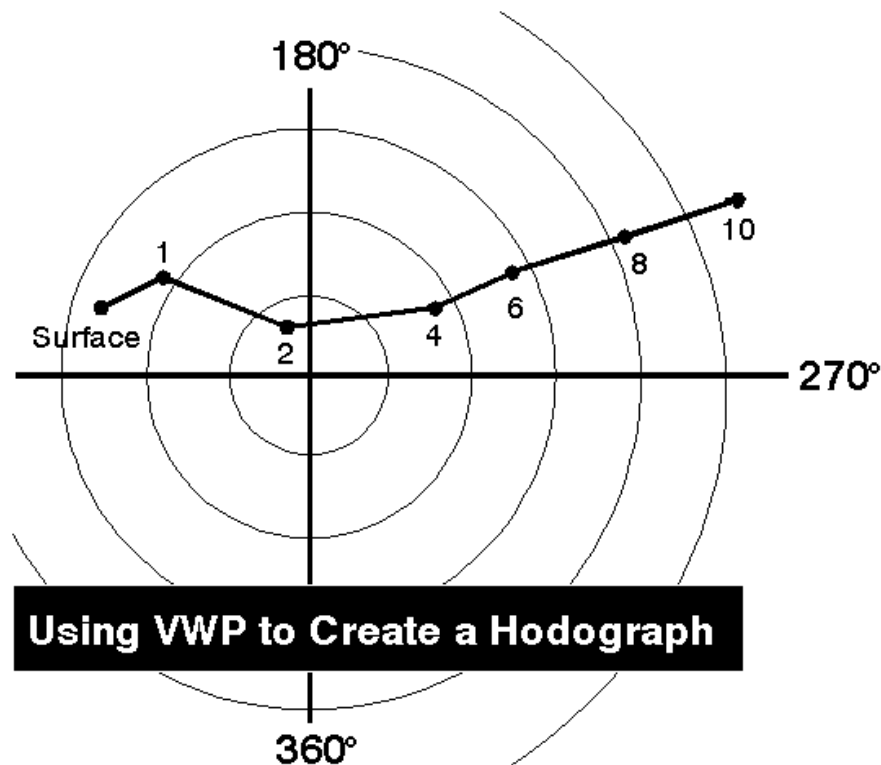


Figure 4-19. The VWP product can be used to create or adjust hodographs.

3. ***Future development may include combining the Storm Tracking Algorithm and VAD Wind Profile to output helicity.***

Interim Summary

1. A scattering of data points and a fitted sine wave curve are used to compute the winds for individual heights.
2. Product used primarily to check wind data that is "suspect" or missing on the VAD Wind Profile.
1. A composite vertical profile of VAD-derived winds at various levels.
2. Excellent tool for meteorologists in weather forecasting, severe weather, hydrology, and aviation.
3. If fewer than 25 data points exist, or the symmetry or RMS thresholds are exceeded, the VAD Wind Profile will display "ND" (no data) for that height.

Velocity Azimuth Display (VAD)

VAD Wind Profile (VWP)

Mesocyclone (M)

Review Of Operator Identified Mesocyclone

Modified NSSL Mesocyclone Definition

- - Small scale rotation closely associated with a convective updraft that meets or exceeds established thresholds for:
 - --Persistence - Minimum of two volume scans
 - --Vertical extent- Shear extends at least 10,000 ft in the vertical
 - --**Shear**
 - Distance between max inbound and max outbound ≤ 5 nm.
 - *Rotational velocity = $\frac{\text{velocity inbound} + \text{velocity outbound}}{2}$ (using mid-range values).*

Mesocyclone Recognition Guidelines

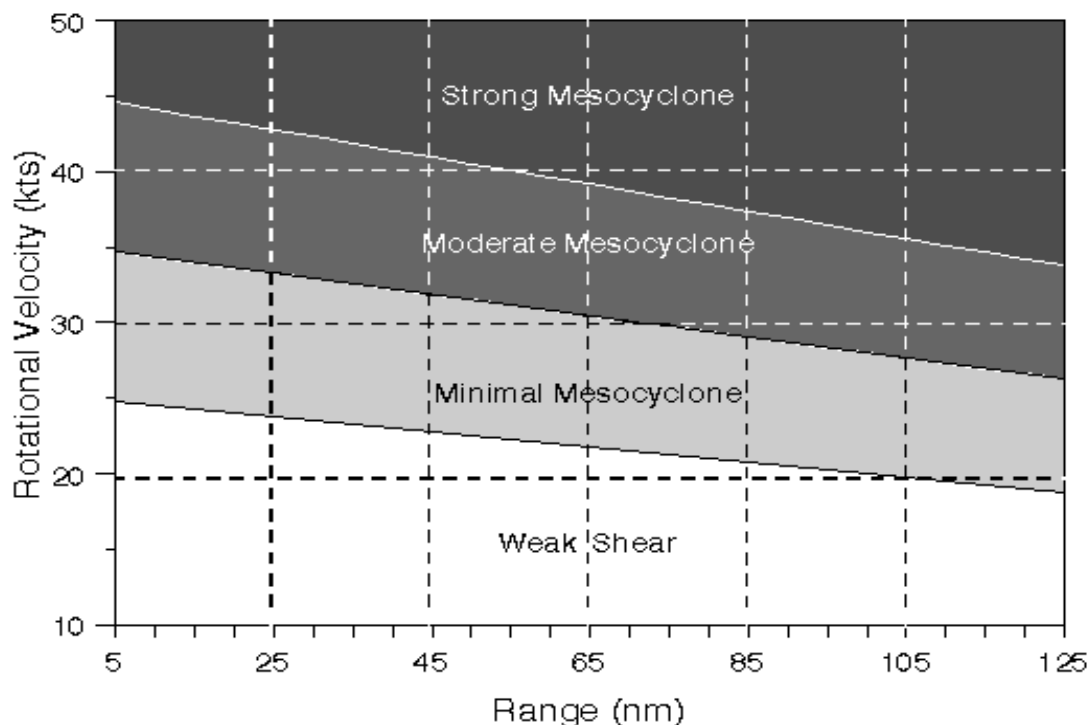


Figure 4-20. Assumes feature diameter of 3.5 nm.

The Mesocyclone Algorithm does not identify mesocyclones the using the same guidelines as an operator.

1. The Mesocyclone Algorithm first searches the dealiased 0.13 nm resolution Mean Radial Velocity data looking for azimuthally adjacent range bins that have a continual increase in Doppler velocity values. A series of these range bins is called a pattern vector.

Mesocyclone Algorithm

Pattern Vectors

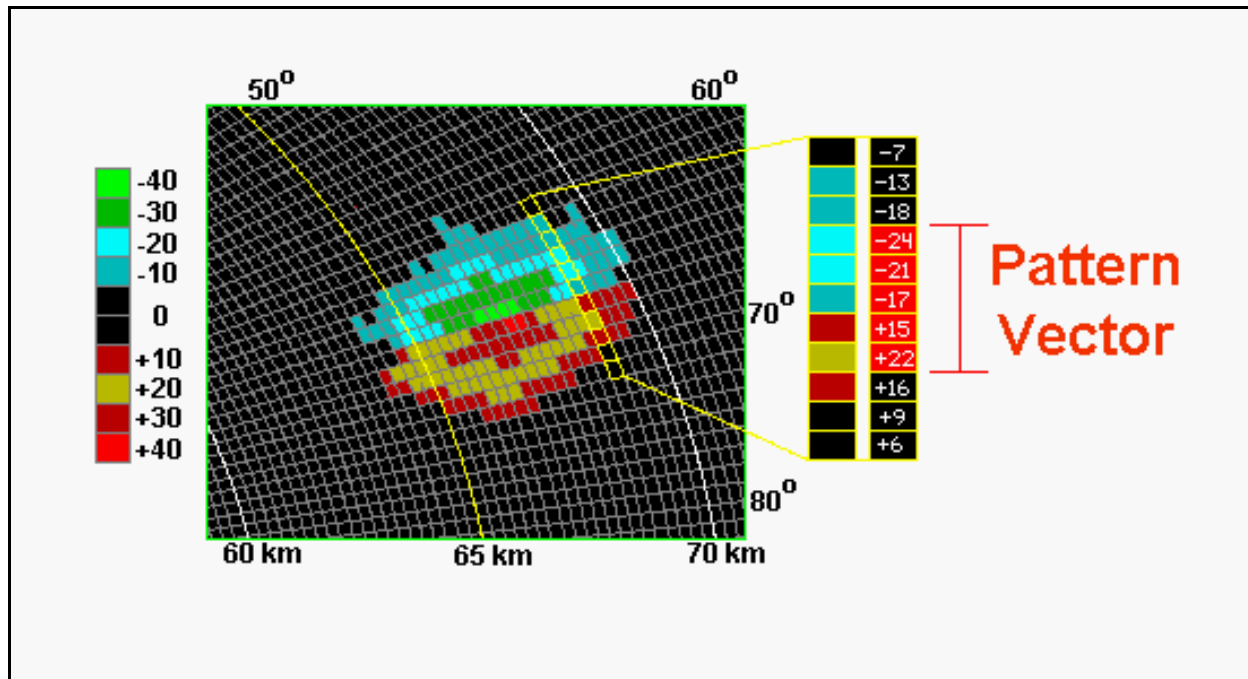


Figure 4-21. The Mesocyclone Algorithm pattern vectors.

2. Measurements are made of the change in velocity from the most negative to the most positive range bin, and the distance between these values. Calculations of **angular momentum** (distance X Δ velocity) and **shear** (Δ velocity / distance) can then be compared to minimum thresholds (adaptable parameters). If these minimum thresholds are not exceeded then the pattern vector is discarded from further processing.

Angular Momentum and Shear

	<p>Mesocyclones often evolve from high angular momentum and low shear in the developing stage, to low angular momentum and high shear in the mature stage. The algorithm allows for both high momentum-low shear features and low momentum-high shear features to be identified as mesocyclones.</p>
2-D Features	<p>3. Pattern vectors at each elevation angle are then consolidated according to their relative spatial proximity. If this group of pattern vectors exceeds a <i>minimum number threshold</i> (adaptable parameter - TPV) they are considered a 2-D Feature.</p>
Symmetry	<p>4. Each 2-D Feature is then tested for <i>symmetry</i>. If the ratio of the 2-D Features <i>radial length</i> to its <i>azimuthal length</i> falls within certain range dependent thresholds, then that 2-D feature is classified as symmetrical. If the ratio falls outside those thresholds the feature is classified as not symmetrical.</p>
Vertical Correlation	<p>5. The 2-D features are correlated with features on elevation angles both above and below. The 2-D features are considered circular for this comparison. The diameter of the circle would be the larger of either radial length, or azimuthal diameter. If the center point of the smaller 2-D feature is vertically located within the area of the larger feature, then the features are considered <i>vertically correlated</i> (3-D Feature).</p>
Three Classifications	<p>6. If a 2-D feature cannot be vertically correlated, then the feature is classified as an <u>Uncorrelated Shear</u>. If two or more 2-D features are vertically correlated, but less than two are classified as symmetrical, the 3-D Feature is classified as a <u>3-D Shear</u>. If two or more of the vertically correlated</p>

features are symmetrical the 3-D feature is classified as a **Mesocyclone**.

The ***Mesocyclone Symbol*** is a yellow circle (the line width is 4 pixels) with the storm ID of the closest identified storm (from the Storm Tracking Algorithm) located just to the SE of the symbol.

The ***3-D Correlated Shear Symbol*** is also a yellow circle (the line width is only 1 pixel), but with no storm ID number.

Both the Mesocyclone and 3-D Shear Symbols are centered at the center point of the lowest 2-D feature. The size of the symbol corresponds to the size of the identified mesocyclone or 3-D shear, but symbol size is unchanged by magnification using AWIPS. This can be misleading! **Don't associate symbol size with the severity of the storm.**

Note that Uncorrelated Shears are not displayed on the graphic product.

See Figure 4-22 for an example of the Mesocyclone product.

Mesocyclone product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Mesocyclone
- PAGE #: This is the page number of the attribute table.
- DATE: Day of week, time, and date in UTC

Mesocyclone product annotations

- Mesocyclone Attribute Table

Mesocyclone Graphic Product Description

Mesocyclone Product Parameters

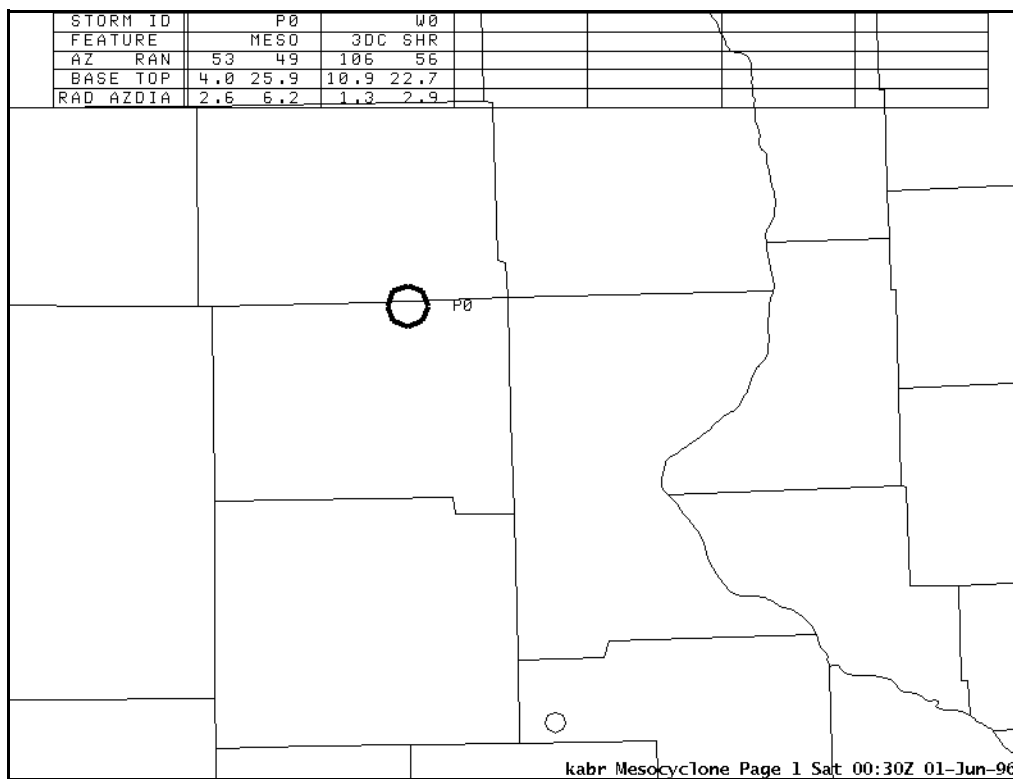


Figure 4-22. Mesocyclone (M) product

Additional Mesocyclone product characteristics

RANGE: 124 nm

Mesocyclone Attribute Table

The Mesocyclone Attribute (color coded yellow) Table is available if any Mesocyclones or 3-D Correlated Shears are detected. If there are Uncorrelated Shears, but no Mesocyclones or 3-D Correlated Shears, the area where the Attribute Table is displayed will be blank. If there are no Mesocyclones, 3-D Correlated Shears, or Uncorrelated Shears, then **“NO MESOS”** is displayed in the Attribute Table area. See Figure 4-23

STORM/ID		P0		W0	
FEATURE		MESO		3DC	SHR
AZ	RAN	53	49	106	56
BASE	TOP	4.0	25.9	10.9	22.7
RAD	AZDIA	2.6	6.2	1.3	2.9

Figure 4-23. Mesocyclone Attribute Table which appears at the top of the MESO product.

The Mesocyclone Attribute table list:

- **-STORM ID** -- of the nearest storm centroid,
- **-FEATURE** -- MESO or 3DC SHR,
- **-AZimuth RANge** -- azimuth in degrees and range in nm (to the center of the feature),
- **-BASE TOP** -- the Base and Top of the feature in kft (ARL) (does not give elevation angles to help the user quickly examine base products), and
- **-RAD AZDIA** --radial and azimuthal diameter.

The Mesocyclone Alphanumeric Product is paired with the Mesocyclone Graphic, and available as a text product in AWIPS (WSRMESxxx). Since most of the information in the alphanumeric product is available on the product or in the Mesocyclone Attribute Table, the only significant operational use is as in indication of the setting for adaptable parameters such as the Total Pattern Vector.

- **-FEAT ID** -- An internal numbering system for the algorithm.
- **-STOR ID** -- This is the ID of the closest storm - not necessarily the storm with the mesocyclone.
- **-FEAT TYPE** -- MESO, 3-DC SHR, or UNC SHR
- **-BASE, TOP** -- base and top in kft (ARL)
- **-AZRAN** -- azimuth and range of feature
- **-HGT** -- height of strongest shear in kft (ARL)
- **-DIAMETER** -- radial length and azimuthal diameter

At the end of the Mesocyclone Alphanumeric Product is a list of adaptable parameters. Changes to these parameters may come about from experience with the radar and low types of convection.

Mesocyclone Alphanumeric Product Description

Mesocyclone Adaptable Parameters

One parameter that is under URC control is Min. # Patrn Vec. The Threshold Pattern Vector (TPV) defines the minimum number of pattern vectors in a 2-D Feature. Sites may change the value from 10 to lower values, but no lower than 6. By lowering TPV, the Mesocyclone Algorithm should detect smaller features such as those associated with low topped convection or mini-supercells. However, this change may generate more false alarms. If the change has a detrimental effect on the algorithm's performance, return the adaptable parameter to its original value of 10.

An example of an ROC adaptable parameter is **MAX HGT MESO** (currently set at 8 km or approximately 26 kft). Any 2D-Feature found above this height is discarded to eliminate transient shears. Since the 1.5° beam height at 110 nm is about 26,000 ft, no mesocyclones or 3D shears would be detected beyond 110 nm. See Figure 4-24.

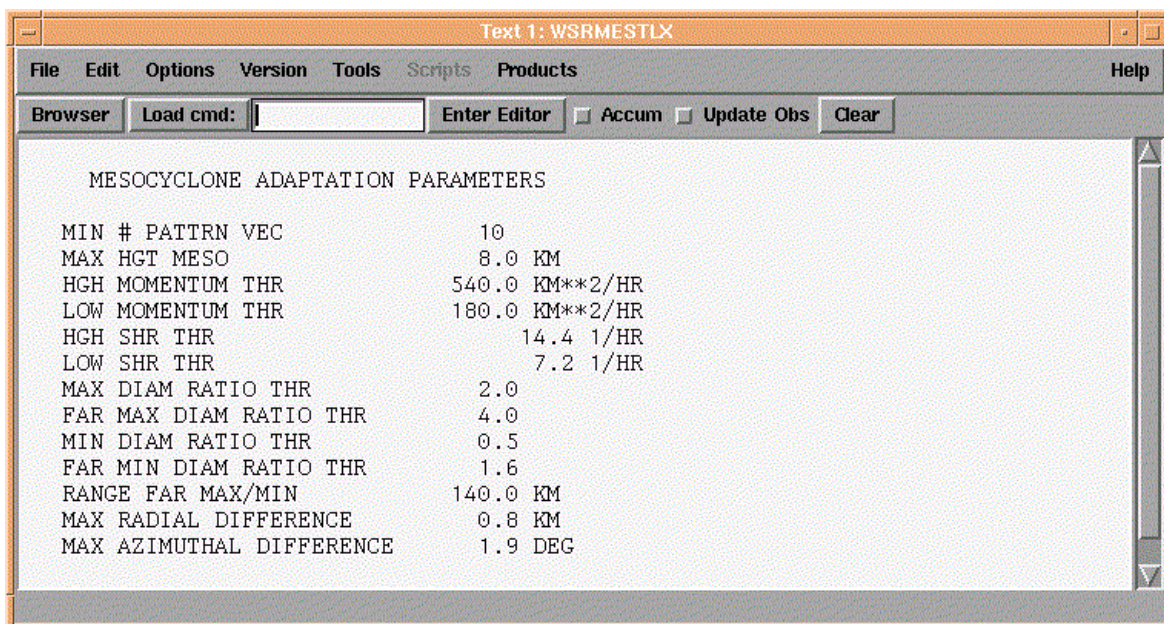


Figure 4-24. Mesocyclone adaptable parameters displayed at the AWIPS Text Display Window.

The Mesocyclone Product is recommended for the RPS List whenever convection is expected.

Since the Mesocyclone Product is usually on the RPS list, other products are often alert-paired with the Mesocyclone Alert. The Storm Relative Mean Radial Velocity Region Product (SRR) or the Severe Weather Analysis Velocity Product (SWV) are “window” products which are often used.

If the operator sets the alert category to be alerted for a mesocyclone, the “window” product sent with that alert is centered at the location of the mesocyclone. The alert categories of 3-D Shear or Uncorrelated Shear are not recommended. One reason is that the “window” product sent with the alert will be centered on the centroid of the closest identified storm. The product area may not include the feature producing the alert.

- 1. Time continuity is not employed.** - The algorithm does not wait for 2 volume scans.
- 2. Does not need 10,000 ft deep circulation.** - The algorithm only requires 2 vertically linked elevation angles.
- 3. *The algorithm only detects cyclonic rotations.***
- 4. Identification is influenced by aspect ratio.**
- 5. Don't know which elevation angle to examine shear.** - Attribute Table and Mesocyclone Alphanumeric Product only give height.
- 6. Range thresholds may discard or improperly classify mesocyclones. No data within 10 km (5.4 nm) is processed by the mesocyclone algorithm.** - Search Base Products for evidence mesocyclones.

Mesocyclone Alerts

Mesocyclone Limitations

Mesocyclones Strengths/ Applications

7. Improper dealiasing may generate false mesocyclones.
8. Algorithm default values adapted for classic supercells.

Tornadic Vortex Signature (TVS)

Review of Operator Identified TVS

Modified NSSL TVS Definition

An intense gate-to-gate azimuthal shear associated with tornadic-scale rotation. A TVS is identified if the gate-to-gate shear is:

≥ 90 kts and the range is < 30 nm

≥ 70 kts and the range is $30 \text{ nm} \leq r < 55 \text{ nm}$

Gate-to Gate Shear = Velocity Difference = | velocity inbound | + | velocity outbound |

Remember that these values are only guidelines, the user will have to adjust according to the situation and geographic location.

Tornado Detection Algorithm (TDA) / TVS Product

The WSR-88D Software Build 10 introduced a new Tornado Detection Algorithm (TDA) replacing the old Tornadic Vortex Signature (TVS) Detection Algorithm. Although the algorithm name changed from TVS to TDA, the WSR-88D product contin-

ued to be called Tornadic Vortex Signature (mnemonic TVS, ID# 61).

The Tornado Detection Algorithm (TDA) was developed at the **National Severe Storms Laboratory (NSSL)** and is designed to detect significant shear regions in the atmosphere. The TDA uses multiple velocity thresholds to locate shear regions, and classifies these regions according to altitude and strength. Performance of the TDA is better than old pre-Build 10 TVS algorithm, with a higher probability of detection, many adaptable parameters, some discrimination between tornadic and non-tornadic shear, and a requirement for gate-to-gate shear. TDA can provide positive lead times for storms that become tornadic.

The Build 10, the Mesocyclone and Tornado Detection algorithms process data separately. This means that ***an algorithm-identified mesocyclone need not exist for a TVS or Elevated TVS (ETVS) to be identified.*** The TDA is modeled after the SCIT algorithm and uses a three step process to identify circulations.

First, 1-D pattern vectors are identified on each elevation slice. In TDA, a pattern vector is a region of gate-to-gate shear, which means the velocity difference is calculated between range bins ***located on adjacent azimuths*** at the same range. A minimum shear value is required for a pattern vector to be identified (see Fig. 4-25). The TDA searches only for patterns of velocity indicating cyclonic rotation. It ***does not*** detect an anticyclonically rotating signature.

Next, 2-D features are created by combining the 1-D pattern vectors (see Fig. 4-26). At least three

Build 10 Tornado Detection Algorithm

TDA Process

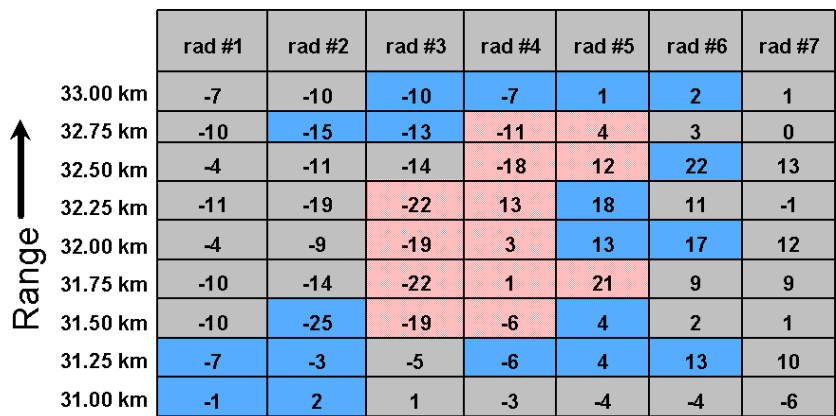


Figure 4-25. All increasing velocities (cyclonic shear) are shaded blue. All TDA Pattern Vectors (>11 m/s shear) are shaded pink.

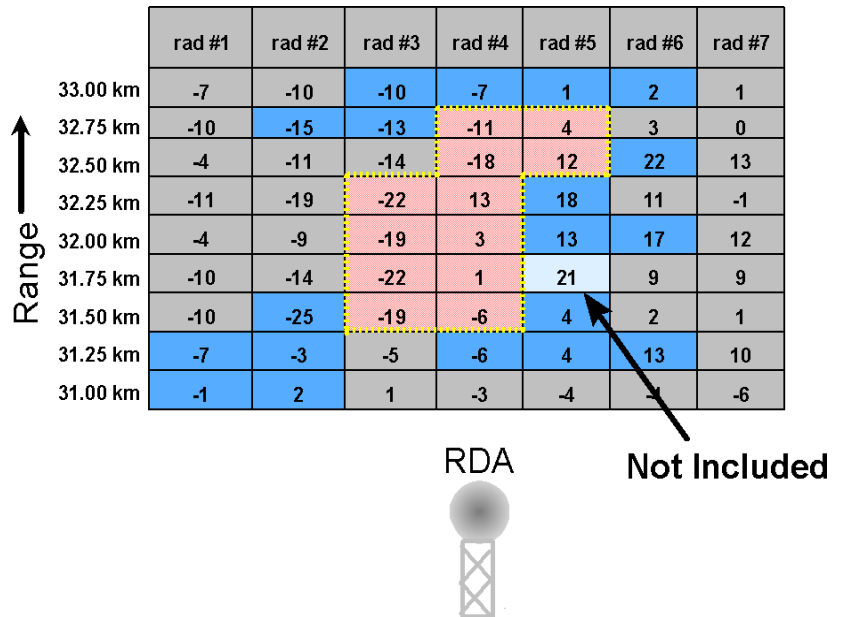


Figure 4-26. 2-D Feature outlined in yellow.

pattern vectors (default) are needed to declare a 2-D feature.

TDA uses six velocity difference thresholds to identify pattern vectors. This technique allows the algorithm to isolate core circulations which may be embedded within regions of long azimuthal shear.

An example would be a radially oriented gust front or squall line. In Figure 4-27, a long segment of shear exceeding 15 m/s has embedded within it a smaller segment of shear greater than 20 m/s, and still smaller segments of shear greater than 25 m/s. If a 2-D feature passes a symmetry test (length to width ratio within a specified limit), it is declared a 2-D circulation.



Figure 4-27. 2-D Features - Multiple velocity thresholds used to identify stronger shear embedded within weaker shear.

Finally, 3-D features are created by vertically correlating the 2-D circulations identified at each elevation (see Fig. 4-28). Processing begins by correlating the strongest 2-D circulations first, then moving to progressively weaker circulations. If a feature contains at least three vertically correlated 2-D circulations, it is declared a 3-D circulation, and identified as either a TVS or an ETVS. Ideally, there will be no gaps in elevation angles between the vertically correlated 2-D circulations. However, a one elevation angle gap is permitted to account for base data problems such as range folding and velocity dealiasing failures.

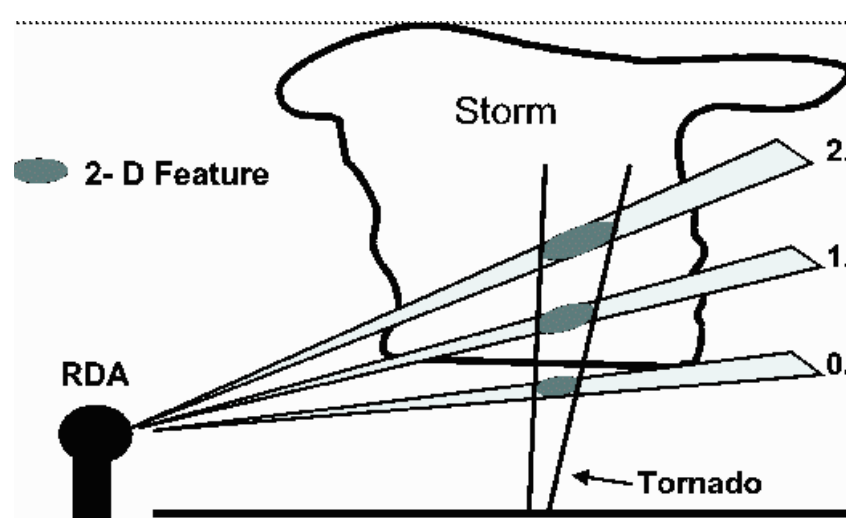


Figure 4-28. Vertically correlated 2-D circulations.

Definitions and Symbology

TVS A Tornadic Vortex Signature, TVS, is defined as a 3-D circulation with a base located on the 0.5° slice **or** below 600 meters ARL (above radar level). The depth of the circulation must be at least 1.5 km. Additionally, the maximum delta velocity anywhere in the circulation must be at least 36 m/s, or at least 25 m/s at the base of the circulation. The TVS symbol is displayed on the graphic product and overlay as a red, filled, inverted triangle. TVS symbols are placed at the azimuth and range of the lowest 2-D feature.

ETVS An Elevated Tornadic Vortex Signature, Elevated TVS or ETVS, is defined as a 3-D circulation with a base above the 0.5° slice **and** above 600 meters ARL. The depth of the circulation must be at least 1.5 km. Additionally, the delta velocity at the base of the circulation must be at least 25 m/s. The ETVS symbol is displayed on the TVS overlay and the TVS graphic product as a red, open, inverted triangle as shown in Figure 4-31, and is placed at the azimuth and range of the lowest 2-D feature.

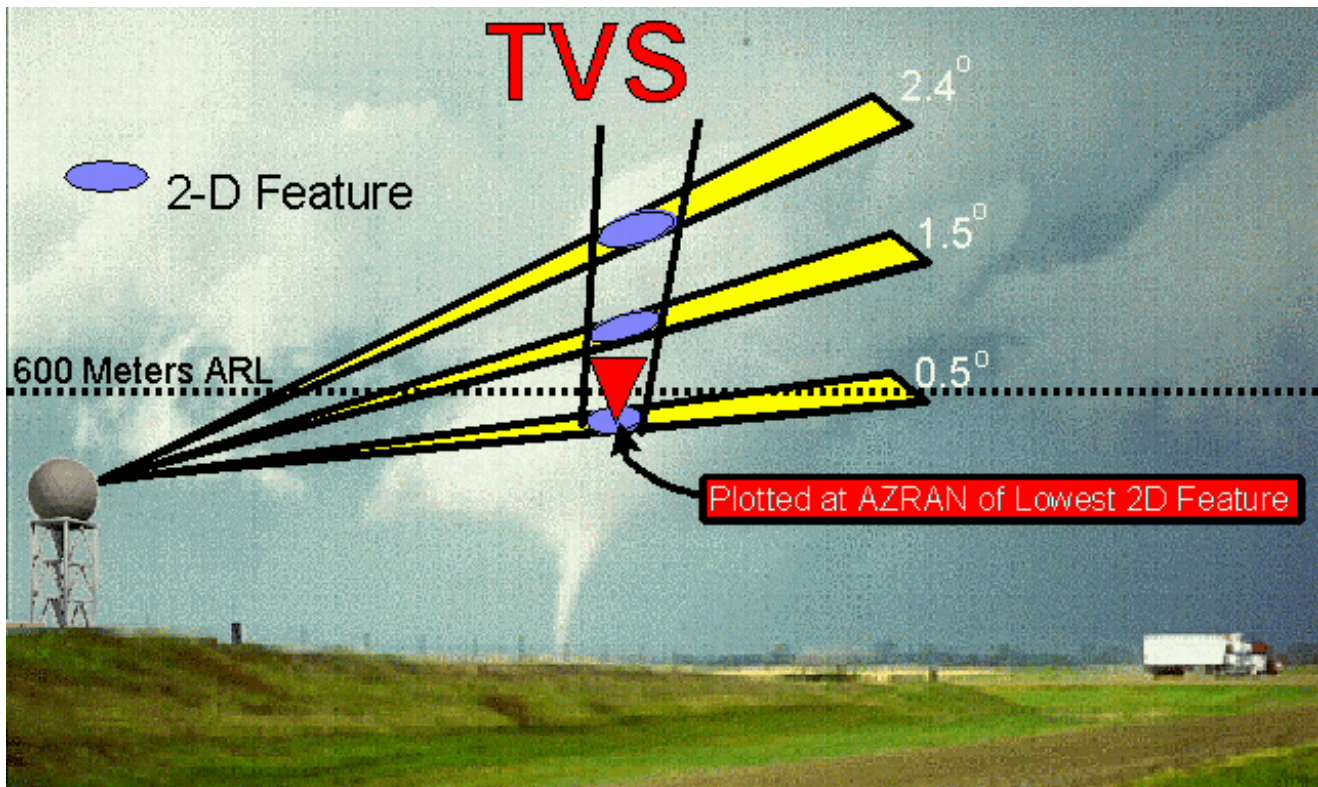


Figure 4-29. TVS definition.

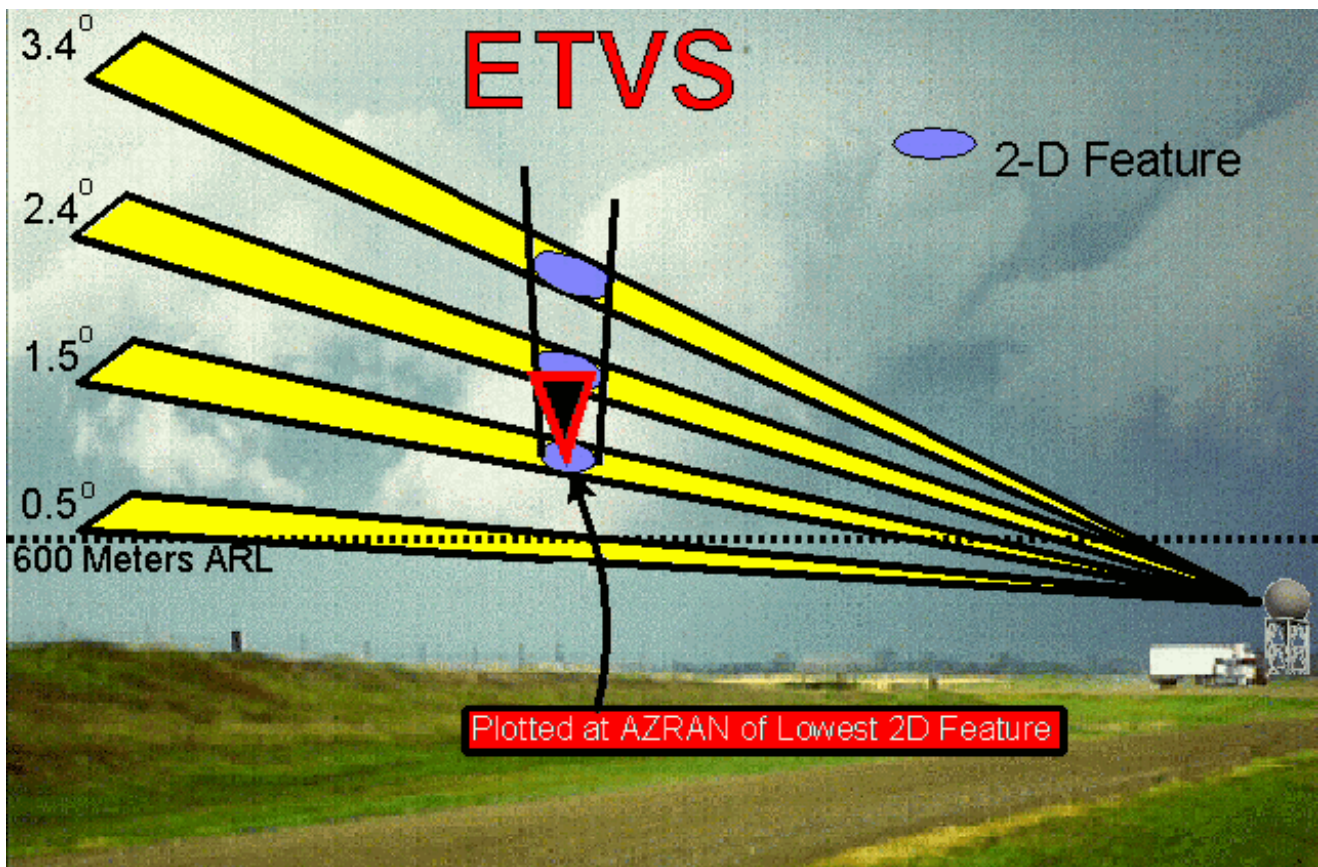


Figure 4-30. ETVS definition.

The default values listed above for depth, delta velocity at the base of the circulation, maximum delta velocity anywhere in the circulation, and height above radar are only **some** of the TDA adaptable parameters.

Note that an Elevated TVS may possess a larger value of maximum shear somewhere in the storm column as compared to a TVS, but if there is no circulation on the 0.5° slice or below 600 meters, it cannot be defined as a TVS, despite possessing the higher shear.

TVS Product Parameters

See Figure 4-31 for an example of the TVS product

TVS product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Tornado Vortex Signature
- PAGE #: This is the page number of the attribute table.
- DATE: Day of week, time, and date in UTC

TVS product annotations

- TVS Attribute Table

Additional TVS product characteristics

- RANGE: 124 nm

Note that an Elevated TVS may possess a larger value of maximum shear somewhere in the storm column as compared to a TVS, but if there is no circulation on the 0.5° slice or below 600 meters, it cannot be defined as a TVS, despite possessing the higher shear.

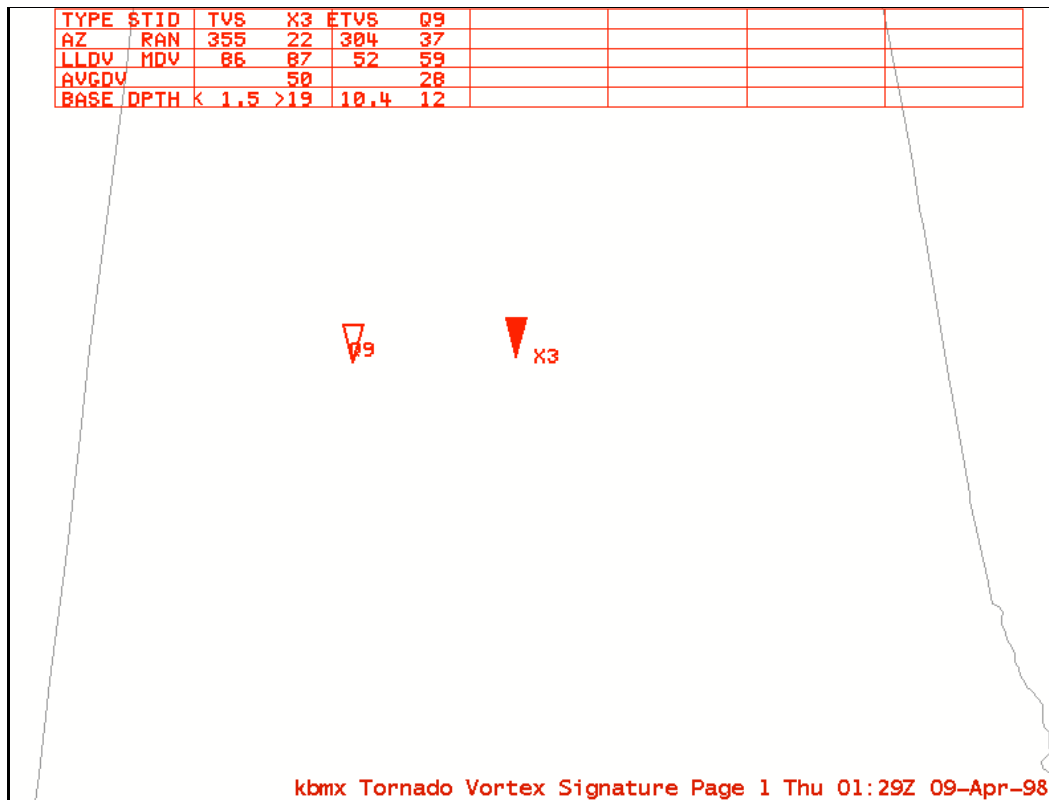


Figure 4-31. Example of TVS graphic product.

The TVS Attribute Table is available if any TVSs or ETVSs are detected. See Figure 4-32.

TYPE	STID	TVS	X3	ETVS	Q9
AZ	RAN	355	22	304	37
LLDV	MDV	86	87	52	59
AVGDV			50		28
BASE	DPTH	<1.5	>19	10.4	12

Figure 4-32. TVS Attribute Table which appears at the top of the TVS product.

- **LLDV:** Low-Level Delta Velocity, in knots (Greatest velocity difference of lowest 2-D circulation)
- **MDV:** Maximum Delta Velocity, in knots (Greatest velocity difference of any 2-D circulation)
- **AVGDV:** Average Delta Velocity, in knots (Average weighted velocity difference of all 2-D circulations)

TVS Attribute Table

Definitions

- **BASE:** Lowest altitude of the 3-D circulation, in Kft (Altitude of the lowest 2-D circulation)
- **DPTH:** Depth of the 3-D circulation, in Kft (Height difference between the lowest and highest 2-D circulation)

If a circulation exists at either 0.5° or 19.5° , then the depth of the circulation (DPTH) is estimated, and a > (greater than) symbol will be displayed with the stated depth. Similarly, if the circulation exists at 0.5° , the base (BASE) of the circulation is estimated, and a < (less than) symbol will be used with the stated base altitude. (See Figure 4-31)

The TVS Adaptation Data can be displayed at the AWIPS Text Display Window (WSRTVSxxx). This can be used to determine the adaptable parameter settings used to generate the product. See Figure 4-33.

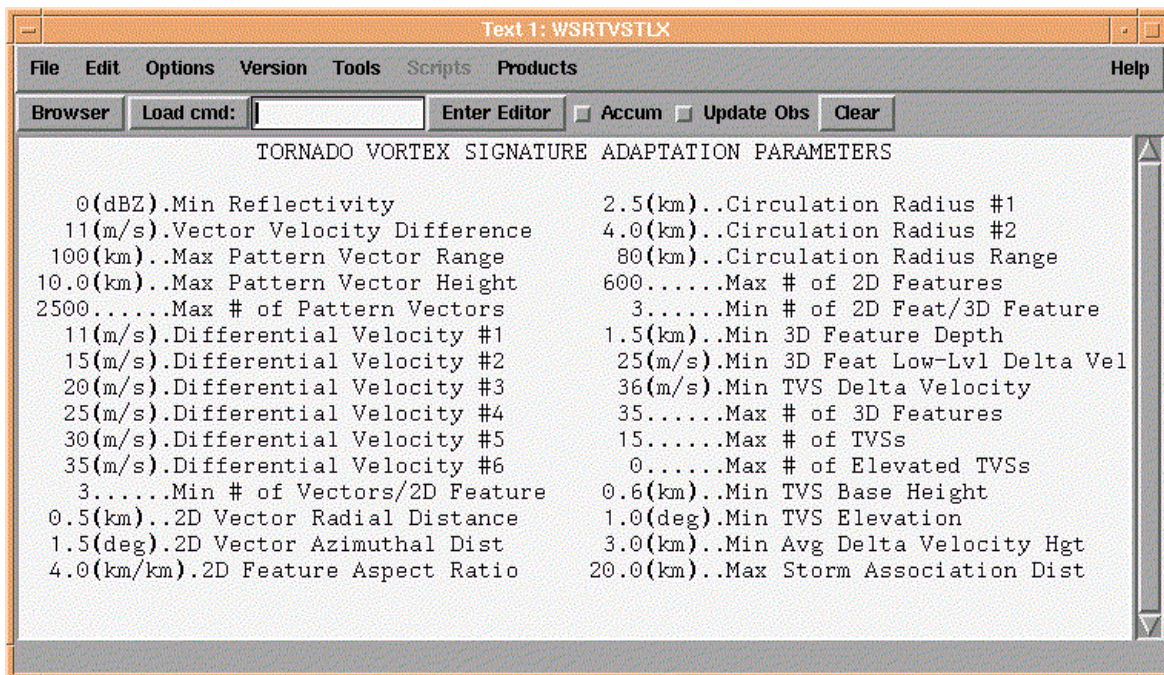


Figure 4-33. TVS adaptable parameters displayed at the AWIPS Text Display Window.

The Tornado Detection Algorithm contains 30 adaptable parameters. The default values for TDA were derived from analyzing algorithm performance while using a large, geographically diverse data set. The ROC recognizes that the default values assigned to the TDA will not work well in all regions of the country and for all weather situations. Therefore, the ROC has delegated authority for changing some of these values to the Unit Radar Committee (URC) level in the form of parameter sets. Currently, there are four parameter sets from which to choose:

1. Default
2. Minimized (Conservative)
3. Isolated Supercell
4. Squall Line/Other

The **default** adaptable parameter set optimizes algorithm performance for all types of storm events. When compared to the Build 9 TVS algorithm, TDA with the **default** parameters produces a much higher POD, meaning that a greater number of tornadic events will be detected (See Table 4-1). The **default** settings also result in a much higher FAR, meaning that a significant number of TVS/ETVS symbols will be displayed for events which are ultimately non-tornadic.

Table 4-1: TVS/TDA Performance

(ETVS not included.)

	Build 9 TVS	TDA (Def)	TDA (Min)	TDA (Supercell)	TDA (Squall/Other)
POD	7	32	2	43	18
FAR	8	61	8	44	77
CSI	7	21	2	32	11

The **minimized** (conservative) adaptable parameter set results in the TDA performing much like the

TDA Adaptable Parameter Sets

Pre-Build 10 TVS algorithm. The **minimized** parameter set gives a POD of tornadic shear less than 5%, meaning that many tornadic circulations will go undetected. The **minimized** setting produces a FAR which is also close to 8%, meaning that if a circulation is detected it is likely significant.

When adaptable parameters are optimized for isolated supercells the algorithm performance improves to a POD of 43% and a FAR of 44%.

Studies of TDA performance for squall line, mini-supercells, and tropical events suggest that neither the default nor the minimized parameter result in the best algorithm output. The **Squall Line/Other** parameter sets were developed to enhance performance during these types of weather situations. However, performance scores for this set indicate additional research is needed.

It must be stressed that no matter which parameter set is selected, only the ROC specified values are to be used. The **RPG Adaptable Parameters Handbook** lists the valid settings for each parameter set in section 6.15 - *Tornado Detection Algorithm*.

Currently, each adaptable parameter set created by the ROC consists of only three editable parameters at the ORPG HCI. The **Minimum 3-D Feature Low-Level Delta Velocity** is the velocity threshold which must be exceeded in the lowest 2-D feature for a circulation to be declared either a TVS or an ETVS. The **Minimum TVS Delta Velocity** is the velocity threshold which must be exceeded at any elevation for a circulation to be declared a TVS. The **Minimum 3D Feature Depth** is the minimum depth required to declare a TVS or

an ETVS (See Fig. 4-34). Note: The individual parameters in each set can not be changed independently and must be changed as a set.

Name	Value	Range
Min Reflectivity	0	-20 <= X <= 20, dBZ
Vector Velocity Difference	11	10 <= X <= 75, m/s
Max Pattern Vector Range	100	0 <= X <= 230, km
Max Pattern Vector Height	10	0 <= X <= 15, km
Max # of Pattern Vectors	2500	1500 <= X <= 3000
Differential Velocity #1	11	10 <= X <= 75, m/s
Differential Velocity #2	15	15 <= X <= 80, m/s
Differential Velocity #3	20	20 <= X <= 85, m/s
Differential Velocity #4	25	25 <= X <= 90, m/s
Differential Velocity #5	30	30 <= X <= 95, m/s
Differential Velocity #6	35	35 <= X <= 100, m/s
Min # Vectors/2D Feature	3	1 <= X <= 10
2D Vector Radial Distance	0.5	0.0 <= X <= 3.0, km
2D Vector Azimuthal Distance	1.5	0.0 <= X <= 4.0, degrees
2D Feature Aspect Ratio	4.0	1.0 <= X <= 10.0, ratio
Circulation Radius # 1	2.5	0.0 <= X <= 10.0, km
Circulation Radius # 2	4.0	0.0 <= X <= 10.0, km
Circulation Radius Range	80	1 <= X <= 230, km
Max # 2D Features	600	600 <= X <= 800
Min # 2D Features/3D Feature	3	1 <= X <= 10
Min 3D Feature Depth	1.5	0.0 <= X <= 5.0, km
Min 3D Feat Low-Lvl Delta Vel	25	0 <= X <= 100, m/s
Min TVS Delta Velocity	36	0 <= X <= 100, m/s
Max # 3D Features	35	30 <= X <= 50
Max # TVS's	15	15 <= X <= 25
Max # Elevated TVS's	0	0 <= X <= 25
Min TVS Base Height	0.6	0.0 <= X <= 10.0 km

Figure 4-34. TVS Adaptable Parameters Edit Screen at ORPG HCI

Three additional TDA parameters are under the URC LOCA. The **Minimum Reflectivity** is the lowest value of reflectivity required for a range bin to be used in a pattern vector. Unit Radar Committees have the authority to change this value between 0 and +20 dBZ. The default value is set to 0 dBZ. Lower values of reflectivity imply that TDA will process more data, increasing CPU usage. Larger values imply that some circulations well outside the storm core may not be included for processing by TDA.

The **Maximum Pattern Vector Range** is the maximum range at which pattern vectors are identified. Unit Radar Committees may adjust this parameter

TDA Adaptable Parameters Under URC Level of Change Authority (LOCA)

to between 100 and 150 km. The default value is set to 100 km (See Figure 4-34).

The **Maximum Number of Elevated TVSs** parameter controls how many ETVSs the algorithm can process per volume scan. The default Build 10 value for this adaptable parameter is set to zero, which means that ETVS features will not be identified unless this parameter is changed. (Allowable values range from 0 to 25). The ROC has delegated the authority to change the Maximum Number of Elevated TVSs to the Unit Radar Committee level.

Additional research is needed on the operational usefulness of ETVS detections.

Users should consider that the output from the TDA is also sent to Other Users via the Combined Attribute Table. The numerical value used for this adaptable parameter not only controls the ETVS detections seen internally on AWIPS or at the PUP, but also how many ETVSs the media will receive.

*Icon Graphics Control
(ETVS Display Toggle)*

Depending on which adaptable parameter settings are invoked, it is possible to have a situation when the display becomes cluttered with Elevated TVS symbols, making product interpretation difficult. For this reason, operators have been given control over whether or not ETVS symbols are displayed on the TVS graphic product and overlay.

The AWIPS workstation radar menu (Build 5.2.1 or later) contains the Icon Control Graphics Edit Screen. Operators can select whether to enable or disable the display of Elevated TVSs. (Figure 4-35).

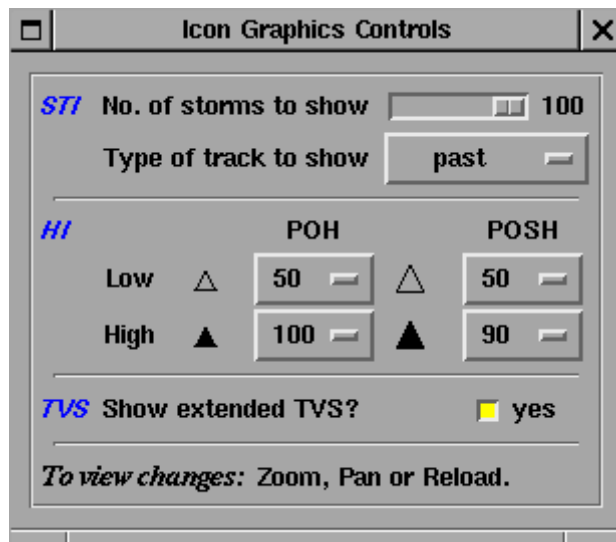


Figure 4-35. Icon Graphics Control Edit Screen.

This toggle does not affect the TVS attribute table or the TVS alphanumeric product or other AWIPS workstations. It is a graphic display function only. Changing the ETVS toggle affects all subsequent TVS products and overlays displayed at the AWIPS Workstation. If the ETVS symbol is toggled to “off”, a situation could arise where outside users are getting ETVSs, but the AWIPS graphic product is not displaying this information.

When a TVS is reported by the new TDA, consider the environmental wind and thermal profile, the signatures position in relation to the storm with which it is associated, time continuity, and the storm's range from the radar. Beyond about 60 km, the TVS will most likely be triggered by a strong mesocyclone and, as experience has shown, not all mesocyclones produce a tornado. Since the TDA works independently of the mesocyclone algorithm, the detection of a mesocyclone coincident with the TVS may support issuing a tornado warning. If the TVS is adjacent to a strong reflectivity gradient especially near the

Operational Considerations

back of a storm, near a notch on the right rear flank of a storm, or near the tip of an appendage attached to the right rear flank of a storm, then the forecaster should give greater consideration to issuing a tornado warning.

Because of its sensitivity, the TDA shows continuity in time and space. TVS detections for the same storm on two or more consecutive volumes can suggest the validity of issuing a tornado warning. The TDA has identified TVSs nearly continuously on long-lived supercells typical of the Great Plains, especially ones that cyclically produce tornadoes. In the South and the Southeast, tornadoes may be embedded within squall lines. ***There is not enough experience available to comment on the performance of this algorithm when tornadoes occur within squall lines.*** The TDA tends to identify TVSs near the bend in a line echo wave pattern along the interface between warm moist inflow and storm outflow. While many of the TVSs are false alarms, tornadoes do occasionally spin up under these conditions.

Elevated TVSs are routinely generated by the TDA, but naturally do not score statistically as well as TVSs. However, ETVSs may be used as indicators of rotation aloft that could, with sufficient vorticity near the ground, produce a tornado. That is, they can be used to provide better lead times for identifying storms with the potential to produce tornadoes. A second use is to fill in gaps in TVS detections. Sometimes vertical continuity cannot be established between the lowest elevation and higher elevations. Other times ground clutter or range folding precludes measuring high gate-to-gate velocity differences. An elevated TVS may provide the time continuity to give a forecaster

confidence to issue a tornado warning. ***One should be cautious about issuing a tornado warning based solely on ETVSs.***

Remember that algorithms serve to provide users with guidance. Ultimately, the decision to issue or not to issue a warning is up to the individual forecaster using all available data, including spotter reports.

1. Adaptable parameters need more research.

Parameters which work well in one type of meteorological setting may not be as effective in other situations.

2. Use of this output may require a change in operational philosophy. Algorithm performance using the ***default*** settings results in a higher False Alarm Ratio. Operators are accustomed to a very low False Alarm Ratio with TVS. A higher FAR with TDA may result in over-warning, or desensitizing forecasters.

3. Little research has been done to date relating the occurrence of tornadoes to Elevated TVSs. Forecasters should use ETVS output with caution until they develop a better understanding of its utility.

Limitations

1. The algorithm searches for gate-to-gate shear, which is more closely related to tornadic circulations.
2. Multiple velocity-difference thresholds make it possible to isolate small regions of shear within broader regions.
3. A distinction is made between different types of shears (TVS vs. ETVS, delta velocity calculations), and more information is provided about the base and depth of circulations.

Strengths

4. The algorithm, through a greater number of adaptable parameters, allows fine-tuning of algorithm performance, resulting in a higher probability of detecting operationally important shear regions.

Interim Summary

1. A signature from the Mesocyclone product must be investigated for validity.
2. If a mesocyclone is detected in the velocity field before the algorithm, don't wait for a mesocyclone symbol from the algorithm to take the appropriate action.
3. Adaptable parameters will need to be adjusted to various climatological regimes.

Mesocyclone Product

1. The TVS product can be useful in alerting the operator of significant and possibly tornadic circulations.
2. Output and performance are highly dependent on the parameter sets used.

TVS Product

Lesson 5: Precipitation Algorithms and Products

This lesson will present the precipitation products generated by the WSR-88D, and the algorithms which produce them.

It is important for operators to have a basic understanding of the precipitation algorithms and how they affect the WSR-88D precipitation products.

Without references, in accordance with standardized instruction, you will be able to:

- a. Identify the strengths and limitations of the Precipitation Processing Subsystem.
- b. Describe the precipitation products produced by the Precipitation Processing Subsystem.
- c. Identify the applications and limitations of the Precipitation products.

Precipitation Detection Function

Precipitation Processing Subsystem

1. Preprocessing
2. Rate
3. Accumulation
4. Adjustment

Objectives

Precipitation Algorithms Section

Overview

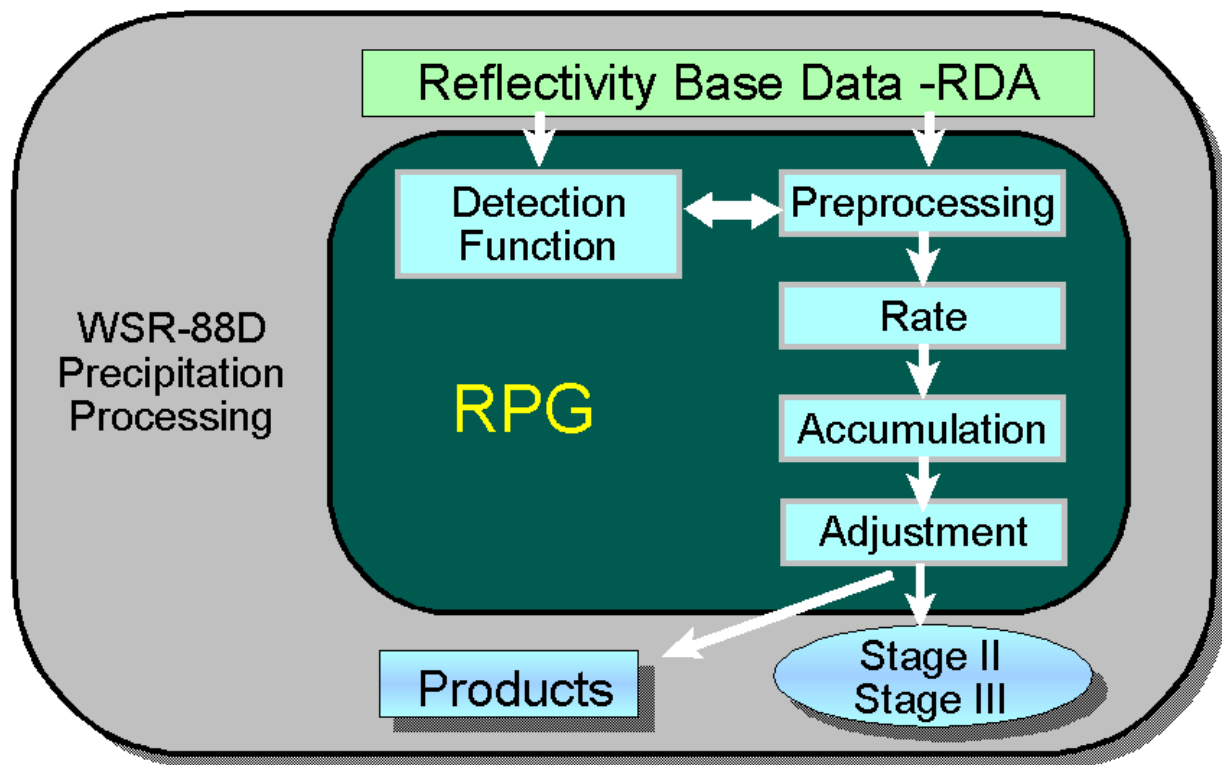


Figure 5-1. WSR-88D Precipitation Processing

Precipitation Detection Function

The purpose of the Precipitation Detection Function (PDF) is to determine if precipitation is occurring within 124 nm of the radar. It utilizes the lowest four elevation angles of the Base Reflectivity Data.

Precipitation Category Thresholds

There are three thresholds used by the PDF.

Precipitation Rate Threshold

Precipitation Rate Threshold (in dBR) - This is echo intensity. At the RPG HCI, the units are in dB of rainfall rate. For better understanding, we will use the dBZ equivalent of these thresholds. This threshold is **not** editable.

Precipitation Area Threshold

Precipitation Area Threshold (in km²) - This is the allowable areal coverage of precipitation-like return without activating the precipitation algorithms. This threshold is **not** editable.

Nominal Clutter Area (NCA) Threshold (in km²) - This value is to be used to account for **residual clutter** contamination whose reflectivity exceeds the precipitation rate threshold. This value **is** editable.

Nominal Clutter Area (NCA) Threshold

Each volume scan, intensity and areal coverage of the reflectivity data (lowest 4 slices), is compared to these thresholds. In order for the algorithms to begin accumulating nonzero precipitation, the intensity and areal coverage must equal or exceed the Precipitation Rate Threshold, **and** the Area Threshold (the **sum** of the Precipitation Area Threshold and Nominal Clutter Area)

While all three parameters are adaptable, the Precipitation Rate and Area Thresholds are ROC controlled, while the Nominal Clutter Area Threshold is URC controlled.

Tilt	Domain	Precip Rate Thrsh (dBR)	Nominal Clutter Area (Km2)	Precip Area Thrsh (Km2)	Precip Cat
0.0	2.0	-2.0	100	20	LIGHT (2)
0.0	4.0	4.0	150	10	SIGNIFICANT (1)
2.0	4.0	-2.0	80	20	LIGHT (2)

To edit, select an item from the table followed by Modify or Delete

Figure 5-2. Precipitation Detection Function screen at the RPG HCI. The Nominal Clutter Area should be used to account for the areal coverage of residual clutter.

A category **detection** means that the rate and areal coverage thresholds for that category have

Category Detection vs Assignment

	<p>been equaled or exceeded for the current volume scan. It does not necessarily mean that the particular category has been assigned. For any particular volume scan, the category that is assigned will control which VCP may be available.</p>
Precipitation Categories Assigned	<p>Each volume scan, a precipitation category number is assigned.</p>
Category 0	<p>Category 0 is defined as no precipitation within 124 nm of the RDA in the past hour. No thresholds are met or exceeded. Once category 0 has been assigned:</p>
<i>VCP Changes</i>	<ol style="list-style-type: none"> 1. If the WSR-88D is in a Clear Air Mode VCP, it will remain there. 2. If the WSR-88D is in a Precipitation Mode VCP, it can be manually switched back to a Clear Air Mode VCP. <p>Note that since category 0 is defined as no precipitation in the past hour, one hour will elapse from the time that category 0 is detected to the time that it is assigned. Once category 0 is assigned, as far as the Precipitation Processing Subsystem is concerned, it's not raining, so the algorithms will be accumulating zeros.</p>
Category 1	<p>Category 1 is defined as significant precipitation within 124 nm of the RDA in the past hour. Significant precipitation may include high precipitation intensities over small areas or low precipitation intensities over large areas. The rainfall is significant from a hydrologic standpoint, where accounting for water in the soil and on the surface becomes important.</p>

The thresholds for category 1 are:

- Precipitation Rate Threshold of 4 dBR = 30 dBZ
- Threshold Area is the sum of the Precipitation Area Threshold of 10 km² and the Nominal Clutter Area

When the category 1 thresholds are equalled or exceeded, then category 1 is assigned. For the volume scan where category 1 is **initially assigned**, there are two possible outcomes:

1. If the WSR-88D is in a Precipitation Mode VCP, the precipitation algorithms will be executed, and the radar will stay in its current VCP.
2. If the WSR-88D is in a Clear Air Mode VCP, a VCP restart with an automatic switch to VCP 21 occurs, and the precipitation algorithms are executed.

Note that since category 1 is defined as significant precipitation **in the past hour**, category 1 will continue to be **assigned** for up to one hour after it is no longer **detected**.

Category 2 is defined as light precipitation within 124 nm of the RDA **in the past hour**. This may include isolated very weak convection or low intensity widespread events.

The thresholds for category 2 are:

- Precipitation Rate Threshold of -2 dBR = 22 dBZ
- Threshold Area is the sum of the Precipitation Area Threshold of 20 km² and the Nominal Clutter Area

For volume scans where category 2 is **assigned**, there is no automatic VCP change, and the algo-

Category 1 Thresholds

VCP Changes

Category 2

Category 2 Thresholds

VCP Changes

	<p>rithms are executed. Category 2 allows accumulations in any VCP, including the Clear Air Mode VCPs.</p> <p>Note that since category 2 is defined as light precipitation <i>in the past hour</i>, category 2 will continue to be <i>assigned</i> for up to one hour in category 0 (<i>detected</i>).</p>
Category changes as the event dissipates	Category 1 supersedes category 2, and will continue to be <i>assigned</i> for one hour <i>after</i> the category 1 thresholds have been met or exceeded.
<i>Category 1 to Category 2</i>	In this case, conditions downgrade to below category 1 thresholds, with category 2 conditions being <i>detected</i> . After one hour, category 2 will be <i>assigned</i> . Once category 2 is assigned, the RPG HCI operator may switch to <i>any</i> desired VCP.
<i>Category 1 to Category 0</i>	In this case, an event downgrades from a category 1 assignment to conditions below <i>both</i> category 1 <i>and</i> 2 thresholds. Category 1 would still be assigned for one hour, then category 0 would be assigned. Once category 0 is assigned, the RPG HCI operator may switch back to a Clear Air Mode VCP.
Clear Air and Precipitation Detection	At times, such as a snow event, Clear Air mode reflectivity data may be desired. VCPs 31 or 32 will display the lower reflectivities down to -28 dBZ. By raising the Nominal Clutter Area for <i>only</i> category 1, and leaving the Nominal Clutter Area low for Category 2, precipitation thresholds (Rate and Area) will be exceeded for category 2, but the thresholds (Rate and Area) will <i>not</i> be exceeded for category 1. Since the thresholds for category 2 and not category 1 have been exceeded, the precipitation is considered by the radar to be category 2. The radar can be run in VCPs 31 or 32, display

lower reflectivities, and still accumulate precipitation in the precipitation products.

Example: Convection occurred in the afternoon and evening with a frontal passage and transition to snow the following morning. The radar is in Clear Air mode during the snow portion of the event. The Storm Total Precipitation product shows that accumulations continued even after the switch back to Clear Air Mode. This switch could only have occurred because of the assignment of category 2.

This method may be advantageous when trying to detect boundaries within your county warning area, and precipitation may be occurring outside your county warning area. This will allow you to keep the radar in a more sensitive VCP, while precipitation products will still be generated for other users, such as River Forecast Centers.

This method must be used with care however. The potential exists for significant storms to develop, without the automatic switch to VCP 21. Do not leave the Nominal Clutter Area for category 1 at a high setting for long periods of time. If storms exceed the reflectivity threshold for category 1, the radar will not automatically switch to VCP 21 unless the areal coverage is also satisfied. It is therefore critical that the nominal clutter area is checked when beginning each shift.

Raising **both** category 1 and category 2 nominal clutter areas is **not** the proper way to keep the radar out of Mode A during Anomalous Propagation. The base data will still be contaminated by the AP unless it is suppressed at the RDA. If returns due to AP are causing the radar to exceed

Word of Warning

Precipitation Detection Status Screen

category 1 or category 2 thresholds, then invoking a Clutter Suppression Region at the RPG HCI is the appropriate way to mitigate that problem.

The Precipitation Detection Status Screen at the RPG HCI (Figure 5-3) contains information relating to the Precipitation Detection Function.

1. The top line ***“Time Until Clear Air”*** annotates the number of minutes left before category 0 or category 2 will be ***assigned***, and the VCP can be changed to clear air mode (VCP 31 or 32). If category 1 is detected, this time will reset to 60 minutes.
2. The middle section has additional information on the detected and assigned category, and the time of category detection
3. The bottom section displays the threshold information pertaining to the category currently being ***detected***. The detected area can be compared to the threshold area to determine an appropriate setting for the nominal clutter area. Note that the detected category may not be the same as the assigned precipitation category found in the top section.

Precipitation Status

Close Modify Parameters Time Until Clear Air: 0 minutes

Detection Algorithm Executed: Nov 3, 1998 - 22:05:51 UT

Category		Time Last Detected	
Current:	NONE (0)	LIGHT (2):	
Previous:	NONE (0)	SIGNIFICANT (1):	

Elevation Angle	Rate (dBR) Thresh	Refl (dBZ) Thresh	Area (km2) Thresh	Detect	Precip Category	Met
No Precipitation Detected						
0.5	-2.0	22.0	120	0	LIGHT (2)	NO
0.5	4.0	30.4	160	0	SIGNIFICANT (1)	NO
1.5	-2.0	22.0	120	0	LIGHT (2)	NO
1.5	4.0	30.4	160	0	SIGNIFICANT (1)	NO
2.4	-2.0	22.0	100	0	LIGHT (2)	NO
2.4	4.0	30.4	160	0	SIGNIFICANT (1)	NO
3.4	-2.0	22.0	100	0	LIGHT (2)	NO
3.4	4.0	30.4	160	0	SIGNIFICANT (1)	NO

NOTE: Threshold Area = Nominal Clutter Area + Precipitation Area

Figure 5-3. Precipitation Status Screen at the OPRG HCI.

The Precipitation Detection Status Screen can be used to determine the appropriate settings for the Nominal Clutter Area (NCA). The detected area gives you areal coverage of returns above the Precipitation Rate Threshold. In cases where the detected area returns are due strictly to residual clutter, a setting of the NCA slightly above the detected area will account for this residual clutter. By doing this on several “typical” days at an office, a “typical” setting for the NCA can be determined.

The Precipitation Detection Function initiates the Precipitation Processing Subsystem (PPS), consisting of four algorithms which contain numerous quality control steps. Since radar only indirectly measures precipitation rates, extensive quality control is applied to get the best possible rainfall estimates. The four algorithms are:

1. Precipitation Preprocessing Algorithm
2. Precipitation Rate Algorithm
3. Precipitation Accumulation Algorithm
4. Precipitation Adjustment Algorithm

Because of the quality control steps used in these algorithms, the operator will notice a difference between the reflectivity data used as input and the corresponding precipitation products.

The PPS provides rainfall estimates out to 124 nm. No estimates are generated beyond 124 nm because errors increase rapidly beyond that range.

Selecting the proper setting for Nominal Clutter Area

Complete run of Precipitation Processing Algorithms

	<p>The algorithms in the PPS are highly flexible with many adaptable parameters. The process of tailoring adaptable parameters for each radar site requires research and observations from the field users of the system. Changes in adaptable parameter settings for a particular office requires coordination with the ROC and the Office of Hydrology.</p>
<p>Precipitation Preprocessing Algorithm</p>	<p>The Precipitation Preprocessing Algorithm uses base reflectivity from the four lowest elevation angles as input (regardless of VCP). This algorithm begins to execute at the end of the fourth elevation scan. The output of this algorithm is the Hybrid Scan Reflectivity (the reflectivity used to convert to rainfall rate).</p> <p>Several quality control checks are made on the base reflectivity data to get the best reflectivity values to convert to rainfall rate.</p>
<p>Base Reflectivity Data Quality Control</p>	<p>Corrections to the data are made to compensate for:</p> <ol style="list-style-type: none"> 1. Ground returns due to anomalous propagation 2. Spurious noise 3. Reflectivity outliers 4. Blockage by terrain
<p>Ground Returns Due to Anomalous Propagation</p>	<p>Although Clutter Suppression is applied at the RDA, the Preprocessing Algorithm attempts to prevent residual clutter from being converted to precipitation. This step does not selectively remove clutter returns. It will either retain the reflectivity from the 0.5° elevation for precipitation processing or it will remove it.</p> <p>The algorithm checks each volume scan to determine if a given percentage of echo areal coverage</p>

disappears from the lowest elevation angle to the next highest elevation angle. Currently, the percent reduction is set at 75%, but is adaptable. It may be set at a value between 25% and 100% with ROC approval. If 75% or more of the echo disappears from the lowest elevation angle to the next highest, the return from the lowest elevation angle is not considered to be precipitation and is no longer used in precipitation processing. This is called the ***“Tilt Test”***.

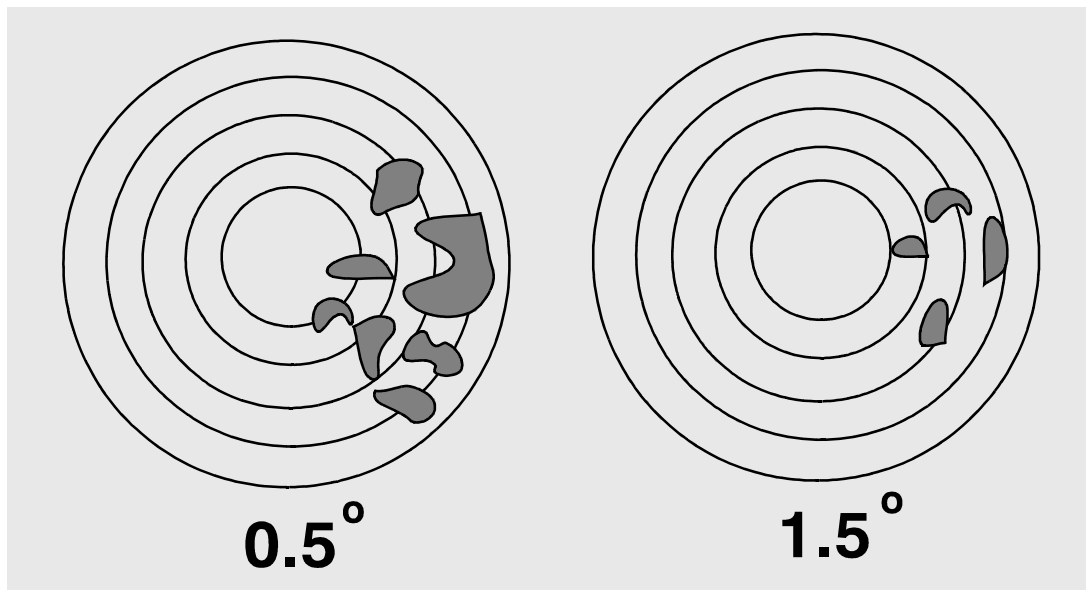


Figure 5-4. Tilt Test

The Preprocessing Algorithm also attempts to correct for unrealistically high reflectivity values caused by system noise or isolated targets such as airplanes, or by contamination from hail. These reflectivities are of two types, isolated reflectivities and reflectivity outliers.

An isolated reflectivity is a value that indicates precipitation, but the range bin is in an area of non-precipitated returns. This may be caused by spurious noise or an airplane flying through the beam.

Spurious Noise and Outliers

Isolated Reflectivities

For radials with blockage of no more than 60%, 1dBZ to 4dBZs are added to the range bins beyond the obstacle (dependent on percentage of blockage). (See Fig. 5-6)

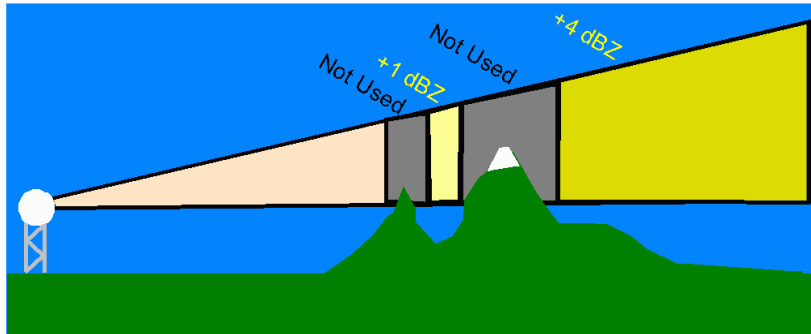


Figure 5-6. Radar Beam Blockage

If more than 60% of the beam is blocked then one of two actions is taken. If the blockage is 2° or less in azimuth, the average value of the range bins next to the blockage, at that elevation angle, is assigned to the blocked range bins. If the blockage is greater than 2° in azimuth, then no correction is made. For that sector, values from the next highest elevation angle would be used.

Bi-Scan Maximization chooses the greater reflectivity of the lowest 2 elevation angles at ranges defined at the RPG HCI. Bi-Scan Maximization is intended to help reduce the effects of beam losses at far ranges. Note that if 0.5° was discarded by the tilt test, then **only** 1.5° is available.

The Bi-Scan Maximization procedure can cause overestimation of precipitation amounts due to

Radials with Blockage

Bi-Scan Maximization

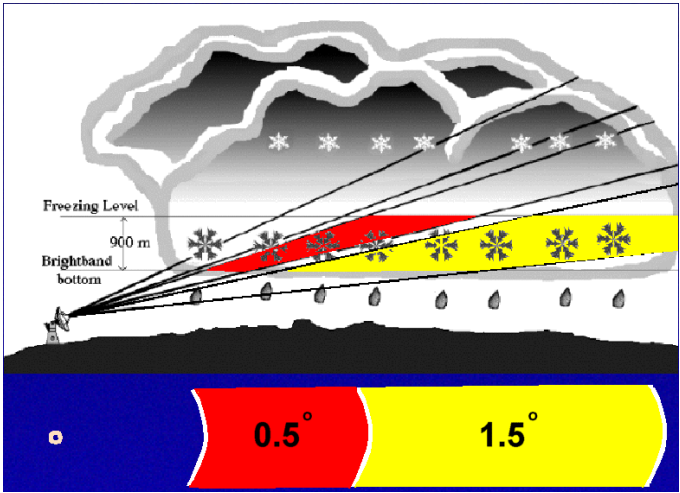


Figure 5-7. Bi-Scan Maximization and the Bright Band

bright band or virga (see Fig. 5-8). This can be minimized by setting the *Min Range of Bi-Scan Maximization* to 230km (identical to the *Max Range of Bi-Scan Maximization*). This would in effect turn off the Bi-Scan Maximization part of the algorithm (see Fig. 5-8).

Algorithms			
Close Save Undo Baseline: Restore Update			
Adaptation Item Hydromet Preprocessing			
Name	Value	Range	
Min Threshold dBZ for Isolated Bin Test [MNRFL]	18.0	-30.0 <= X <= 30.0, increments of 0.5 dBZ	
Max dBZ Allowed Before Being Labelled as Outlier [MXRFL]	70.0	50.0 <= X <= 70.0, increments of 0.5 dBZ	
Tilt-Test Low Reflectivity (dBZ) Value [RFTLT]	1.0	0.0 <= X <= 20.0, dBZ	
Inner Range Limit for Tilt Test [IRTLT]	40	0 <= X <= 150, km	
Outer Range Limit for Tilt Test [ORTLT]	150	40 <= X <= 230, km	
Min Range of Bi-Scan Maximization [MNRBI]	180	0 <= X <= 230, km	
Max Range of Bi-Scan Maximization [MXRBI]	230	0 <= X <= 230, km	
Min Precip Area Echo Needed for Tilt Test in Low Elev [MNECE]	600	100 <= X <= 3000, km**2	
Min Area-Wgtd-Reflect Needed for Tilt Test in Low Elev [MNRRA]	10.0	0.0 <= X <= 20.0, dBZ	
Max % Area Reduction Between 2 Lowest Elevations [MXPCT]	75	0 <= X <= 100, %	
Min dBZ for Converting to Precip Rate (via table lookup) [MNDEZ]	0.0	-32.0 <= X <= 20.0, dBZ	
Max dBZ for Converting to Precip Rate (via table lookup) [MXDEZ]	70.0	50.0 <= X <= 90.0, dBZ	

Figure 5-8. Precipitation Preprocessing Algorithm adaptable parameters edit screen at RPG HCI

Results of Preprocessing Algorithm

The output from the quality control steps of the Preprocessing Algorithm is the 1° x 0.54 nm hybrid scan, which selects the best available estimate of

low level reflectivity for conversion to rainfall rate. In addition to the remaining precipitation algorithms, the hybrid scan is the input for the generation of the Radar Coded Message.

Digitized Base Reflectivity Data from the four lowest elevation angles are transmitted to the RPG for processing.

The Precipitation Detection Function assigns a Precipitation Category each volume scan.

The Preprocessing Algorithm performs quality control steps, resulting in the construction of the Hybrid Scan.

HSR product legend description:

- RPG ID: kxxx
- PRODUCT NAME: 4 bit Hyb Scan Refl
- UNITS: (dBZ)
- DATE: Day of week, time, and date **in UTC**

HSR product annotations:

- VCP: 11, 21, 31 or 32

Additional HSR product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 0.54nm X 1 degree
- DATA LEVELS: 16 data levels from +5 dBZ to + 75 dBZ.

Available every volume scan

A 16 data level reflectivity product from the four lowest elevation angles of base reflectivity.

Interim Summary - Input to Precipitation Processing

Hybrid Scan Reflectivity (HSR)

Note: Do not confuse the HSR product with the Digital Hybrid Scan Reflectivity (DHR).

Hybrid Scan Reflectivity Applications

1. View reflectivity used for precipitation products.
2. Assess the accuracy of the precipitation products.
3. Quickly search for inconsistencies in the data.
4. Assist operator in discriminating between precipitation returns and ground returns due to anomalous propagation.

Hybrid Scan Reflectivity Limitations

1. Tilt test may eliminate valid returns at 0.5° .
2. Bi-Scan Maximization may increase negative impact of bright band contamination.

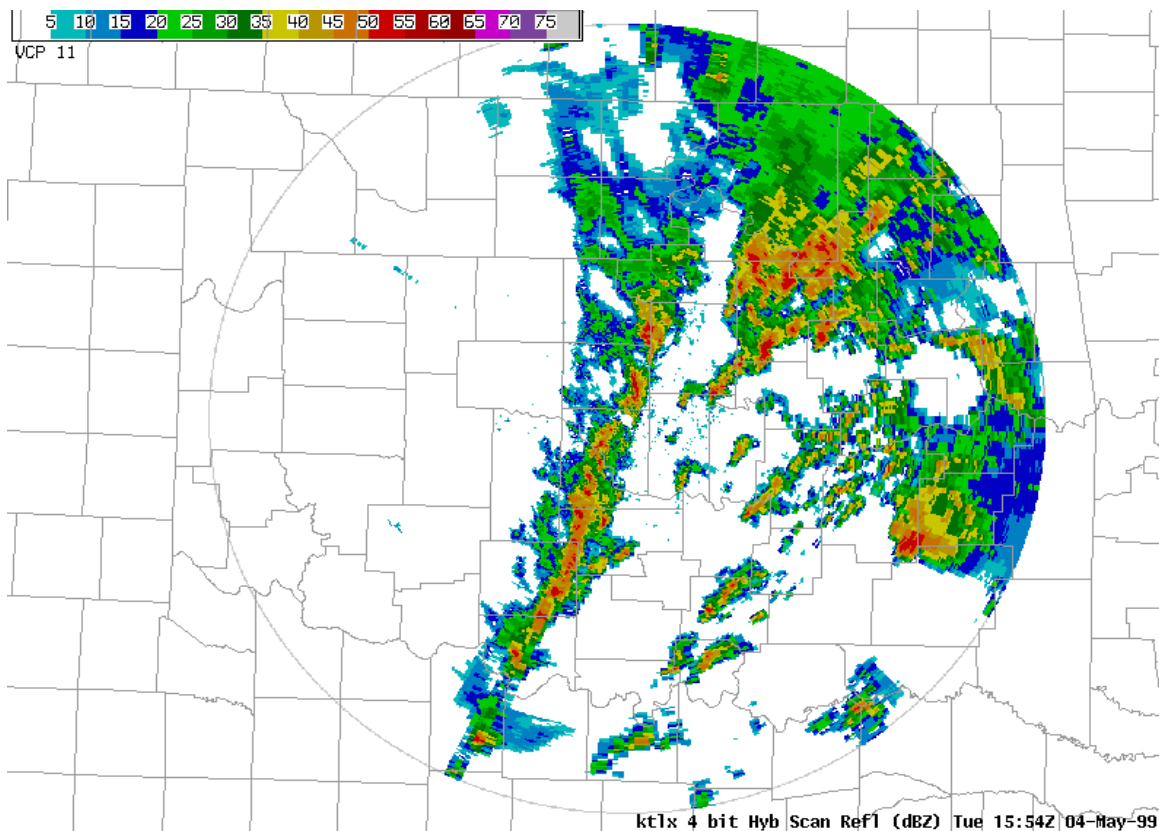


Figure 5-9. Hybrid Scan Reflectivity

DHR product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Hybrid Scan Refl
- UNITS: (dBZ)
- DATE: Day of week, time, and date **in UTC**

DHR product annotations:

- VCP: 11, 21, 31 or 32

Additional DHR product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- DATA LEVELS: 256 data levels from -28 dBZ to + 90 dBZ. (0.5 dBZ increments)

Available every volume scan.

Digital Hybrid Scan Reflectivity (DHR)

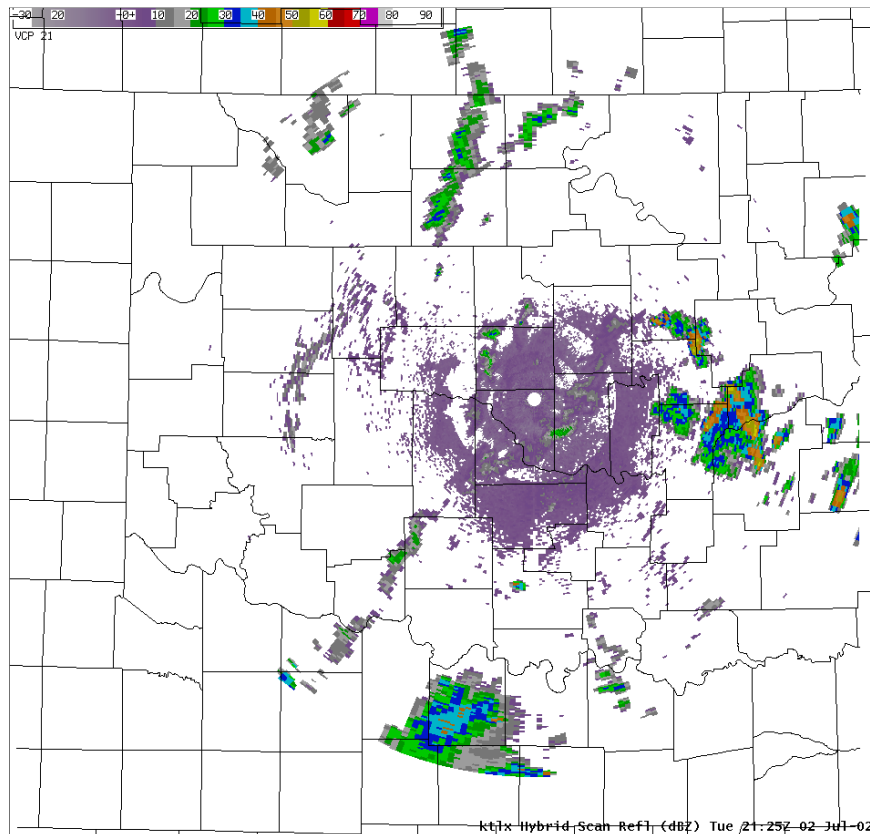


Figure 5-10. Digital Hybrid Scan Reflectivity (DHR)

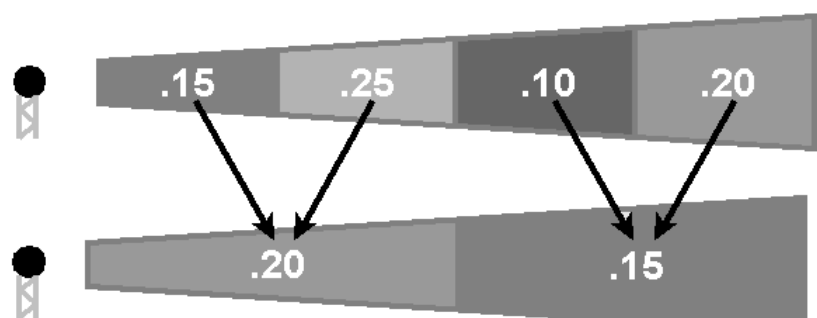
	Displays reflectivity data (from the four lowest elevation angles) used to produce the precipitation products.
DHR Applications	<ol style="list-style-type: none"> 1. High resolution (256 data levels) allows for innovative color tables. 2. High accuracy (0.5 dBZ). 3. Used in the generation of external products. <ul style="list-style-type: none"> • Flash Flood Monitoring and Prediction (FFMP) • Jendrowski Scripts (Multiple Z/R AWIPS App) • Areal Mean Basin Estimated Rainfall (AMBER)
DHR Limitation	<ol style="list-style-type: none"> 1. Large product size
Precipitation Rate Algorithm	<p>The input to the Precipitation Rate algorithm is the best possible low level reflectivity value at each $0.54 \text{ nm} \times 1^\circ$ range bin that was created by the Preprocessing Algorithm (Hybrid Scan). The reflectivity data (dBZ) are converted to rainfall rates (dBR, decibels of R, $\text{dBR} = 10 \log R$) using a Z-R relationship. The Rate Algorithm then performs a resolution change.</p>
Converts $0.54 \text{ nm} \times 1^\circ$ rate data to $1.1 \text{ nm} \times 1^\circ$	<p>The rainfall rates at the $0.54 \text{ nm} \times 1^\circ$ resolution are converted to a new resolution, $1.1 \text{ nm} \times 1^\circ$. This is done by averaging the rates in two adjacent 0.54 nm range bins, and placing the average in the corresponding 1.1 nm bin.</p>
	

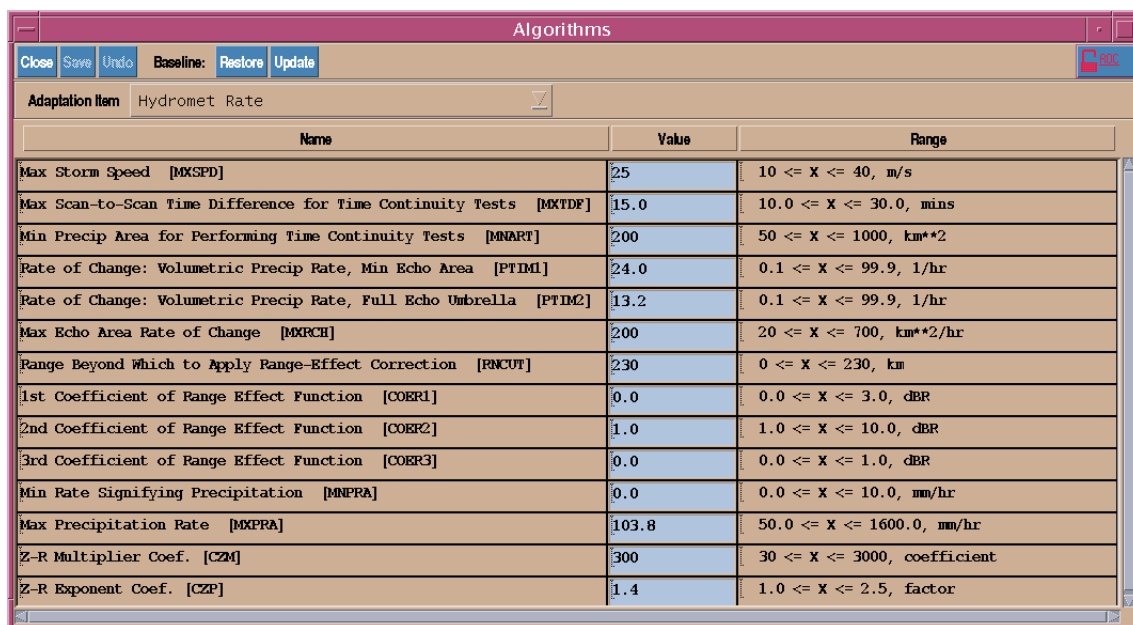
Figure 5-11. Rate Algorithm resolution conversion process

The parameter *Maximum Precipitation Rate Allowed* should correspond to the Z/R relationship used. The default setting is 103.8 mm/hr, which equates to 4.09 in/hr (see Fig. 5-8). This value corresponds to the default Z/R relationship ($300R^{1.4}$). If the Z/R relationship is changed, a corresponding change to the *Max Precipitation Rate* should also be made.

Currently, a tropical and three stratiform specific Z/R relationships that can be invoked at the RPG HCI. With any of these Z/R relationships invoked and *Maximum Precipitation Rate Allowed* left at its default setting, rainfall rates would still be capped at 4.09 in/hr. This could cause significant underestimation using the tropical Z/R relationship ($250R^{1.2}$). When using the tropical Z/R, the *Max Precipitation Rate* should be changed to 154.2 mm/hr, which equates to 6.00 in/hr. For more information on the various Z/R relationships review the Precipitation Estimation section of IC 5.3.

Maximum Precipitation Rate Allowed

Maximum Precipitation Rate Allowed Implications



Name	Value	Range
Max Storm Speed [MXSPD]	25	10 ≤ X ≤ 40, m/s
Max Scan-to-Scan Time Difference for Time Continuity Tests [MXTDF]	15.0	10.0 ≤ X ≤ 30.0, mins
Min Precip Area for Performing Time Continuity Tests [MNART]	200	50 ≤ X ≤ 1000, km ²
Rate of Change: Volumetric Precip Rate, Min Echo Area [PTIM1]	24.0	0.1 ≤ X ≤ 99.9, 1/hr
Rate of Change: Volumetric Precip Rate, Full Echo Umbrella [PTIM2]	13.2	0.1 ≤ X ≤ 99.9, 1/hr
Max Echo Area Rate of Change [MXRCH]	200	20 ≤ X ≤ 700, km ² /hr
Range Beyond Which to Apply Range-Effect Correction [RNCUT]	230	0 ≤ X ≤ 230, km
1st Coefficient of Range Effect Function [COER1]	0.0	0.0 ≤ X ≤ 3.0, dBR
2nd Coefficient of Range Effect Function [COER2]	1.0	1.0 ≤ X ≤ 10.0, dBR
3rd Coefficient of Range Effect Function [COER3]	0.0	0.0 ≤ X ≤ 1.0, dBR
Min Rate Signifying Precipitation [MNPRA]	0.0	0.0 ≤ X ≤ 10.0, mm/hr
Max Precipitation Rate [MXPPRA]	103.8	50.0 ≤ X ≤ 1600.0, mm/hr
Z-R Multiplier Coef. [CZM]	300	30 ≤ X ≤ 3000, coefficient
Z-R Exponent Coef. [CZP]	1.4	1.0 ≤ X ≤ 2.5, factor

Figure 5-12. Hydromet Rate Algorithm adaptable parameters edit screen at RPG HCI.

Precipitation Accumulation Algorithm

The Precipitation Accumulation algorithm takes the output from the Precipitation Rate algorithm (rainfall rates for each 1° X 1.1 nm bin) and produces scan to scan and hourly accumulations for each 1° X 1.1 nm range bin. The Precipitation Accumulation algorithm also checks for missing rate scans.

Scan-to-Scan Accumulations

The volume scan to volume scan accumulations are produced for the Storm Total Precipitation Product. The Storm Total will update each volume scan for the duration of category 1 or 2.

Hourly Accumulations

There are two types of hourly accumulations that generate products:

1. One hour ending at the current volume scan

The first type of hourly accumulation is one hour ending at the current volume scan, and is used to produce the One Hour Product. The One Hour Product is a **moving** one hour window that is updated:

- every 5 or 6 minutes if in mode A
- every 10 minutes if in mode B

2. One hour ending at the top of each hour

The second type of hourly accumulation is one hour ending at the top of the hour. Two out of three top of the hour (or clock hour) accumulations are required to produce a Three Hour Product. This product is available each volume scan, but the accumulations are updated **only** at the top of each hour.

Example

Rain starts at 2:43 PM and stops at 4:30 PM.

The first nonzero accumulation would be one hour ending at 3:00 PM. The second nonzero accumulation would be one hour ending at 4:00 PM, and the third would be one hour ending at 5:00 PM.

The Three Hour Product would be available the first volume scan after 3:00 PM, since two top of the hour accumulations would be available:

- 1:00 - 2:00, zero accumulation
- 2:00 - 3:00, nonzero accumulation

The User Selectable Precipitation (USP) Product is also created using top of the hour accumulations. Two thirds of the requested time period must be available for product generation. Like the Three Hour Product, the USP is available each volume scan, but will only contain accumulations ending at the top of the clock hour.

The Accumulation algorithm also checks for and attempts to correct for missing rate scans. As the time between scans increases, so also increases the error in the precipitation estimate. For example, an outage time of 10 minutes statistically results in 15% error, while an outage time of 15 minutes results in 25% error. In this setting, an outage is any type of failure that prevents base data from being received at the RPG.

Check for Missing Data

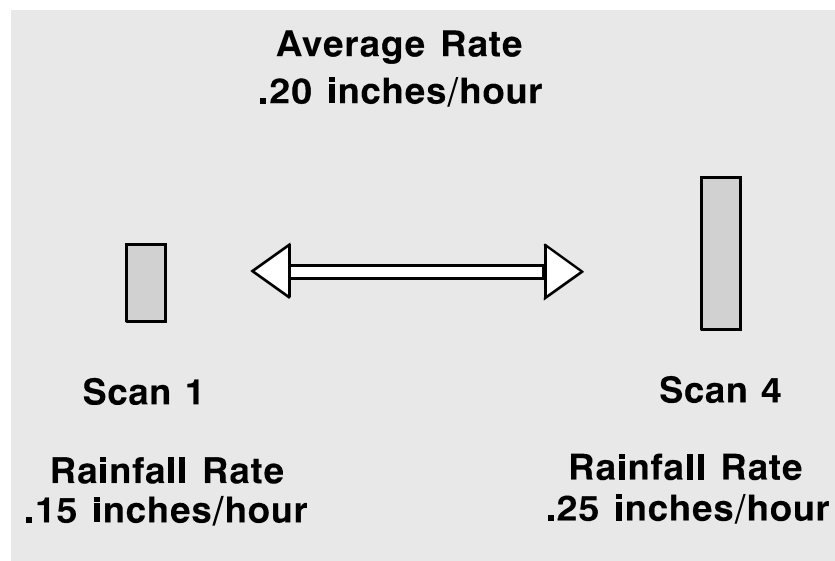


Figure 5-13. Radar outage less than 30 minutes. No data are labeled missing.

In the Accumulation algorithm, if the time between consecutive scans is less than or equal to 30 minutes, the precipitation rates are averaged between the last good volume scan and the first good one. This average is then multiplied by the time between scans (outage time), to compute an accumulation. See Fig. 5-13.

If the time between consecutive volume scans is greater than 30 minutes, the Accumulation algorithm extrapolates the rate from the last good volume scan for an additional 15 minutes. The final 15 minutes of the outage is assigned the rate from the first good volume scan after the outage. The excess time between these two extrapolations is labeled missing. See Fig. 5-14.

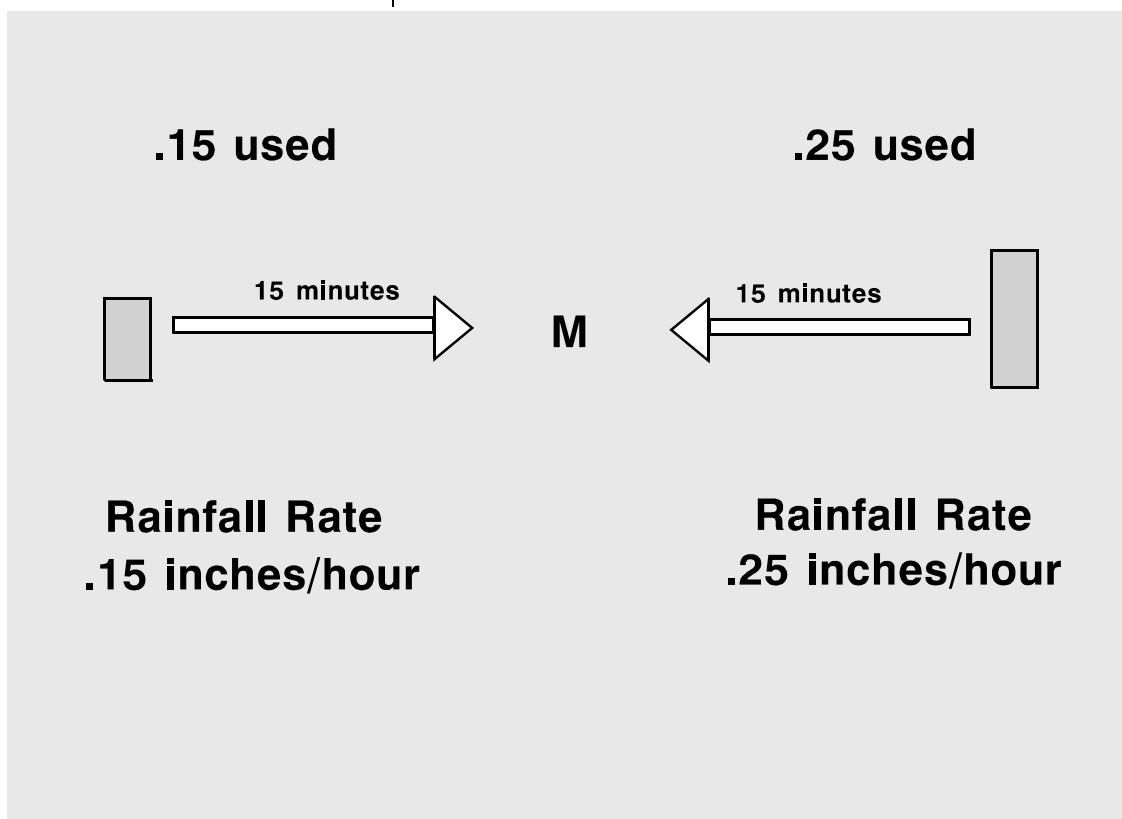


Figure 5-14. Radar outage longer than 30 minutes. Data beyond 30 minutes are labeled missing.

If missing data exceeds 6 minutes (radar outage exceeds 36 minutes), hourly accumulations are not computed.

1. One Hour Product not generated.
2. Three Hour Product not generated until 2 top of the hour accumulations (zero or nonzero) are available. This product may include missing data.
3. The User Selectable Precipitation Product is not generated unless 2/3 of the requested hourly accumulations are computed. When generated, the product may then contain periods of missing data. Missing data periods are listed on the USP attribute table.
4. Storm Total Product will be generated though data are missing.

In category 0, “zeros” are accumulated; a zero accumulation is **not** missing data.

Interim Summary

The Preprocessing Algorithm applies several quality control steps to the Base Reflectivity data and constructs the Hybrid Scan.

The Rate Algorithm converts Reflectivity to Rain-fall Rate and changes resolution from $0.54 \text{ nm} \times 1^\circ$ to $1.1 \text{ nm} \times 1^\circ$

The Accumulation Algorithm computes scan-to-scan and hourly accumulations and checks for missing periods of data.

As of AWIPS Build 5.2.2, a new attempt will be made to correct for two errors that have proven difficult:

1. Non-representative Z-R relationship
2. Incorrect hardware calibration

The WFO version of AWIPS Build 5.2.2 will generate Bias Tables using the AWIPS Multisensor Precipitation Estimator (MPE) function. These tables will be transmitted on a regular hourly basis (or more frequently at operator discretion) to the RPG associated with that WFO. The Bias Table reflects gage/radar differences over various time scales, and is input to the Precipitation Adjustment Algorithm at the RPG.

A Bias Flag (True/False) is set at the RPG to determine whether the multiplicative bias will be used or not. If the Bias Flag is set to True a multiplicative Bias will be made to the both the scan-to-scan and hourly accumulation over the entire 124 nm range.

Precipitation Adjustment Algorithm

Name	Value	Range
Minutes After Clock Hour When Bias is Updated [TBIES]	50	50 ≤ X ≤ 59, mins
Threshold # of Gage/Radar Pairs Needed to Select Bias from Table [NGRPS]	10	6 ≤ X ≤ 30
Reset Value of Gage/Radar Bias Estimate [RESBI]	1.0	0.5 ≤ X ≤ 2.0
Spare No1	0.5	0.1 ≤ X ≤ 0.8, mean square error
Spare No2	0.8	0.1 ≤ X ≤ 0.8, mean square error
Longest Time Lag for Using Bias Value from Table [LGLAG]	168	100 ≤ X ≤ 1000, hrs
Spare No3	12.0	6.0 ≤ X ≤ 48.0, mean square error
Spare No4	0.1	0.0 ≤ X ≤ 0.5, mean square error
Spare No5	0.5	0.0 ≤ X ≤ 10.0, mean square error
Spare No6	2.0	0.0 ≤ X ≤ 10.0, mean square error
Spare No7	400	25 ≤ X ≤ 1600, mm
Spare No8	0.6	0.1 ≤ X ≤ 25.4, mean square error
Bias Flag	False	False, True

Figure 5-15. Hydromet Adjustment Algorithm adaptable parameters edit screen at RPG HCI.

Bias Effect on Products

When the Bias Flag is set to true, the bias is applied differently on the precipitation products.

- One Hour Precipitation (OHP) - Bias applied to entire hour of accumulation.
- Three Hour Precipitation (THP) and User Selectable Precipitation (USP) - Each top-of-the-hour's bias used.
- Storm Total Precipitation (STP) - Each volume scan bias used

A Word of Caution

The Bias Flag default is False. Caution should be used when setting the Bias Flag to True. The bias is available to correct for non-representative Z-R relationships or incorrect hardware calibrations. Bias values may be produced by other factors such as rain gage inaccuracies and below beam effects (strong winds, evaporation, or coalescence). Also the sampling area of a rain gage is considerably smaller than the radar range bin, especially at long ranges.

Precipitation Processing Subsystem - Strengths

Only source of real time high resolution rainfall accumulations.

Significant quality controls are designed to produce better products by:

1. minimizing overestimation due to ground return caused by anomalous propagation,
2. eliminating reflectivity outliers and spurious noise, and
3. reducing the effects of beam blockage.

Algorithms do not account for:

1. below beam effects (wind, evaporation, coalescence),
2. non-uniform Z/R relationships within the radar coverage area.

Algorithms do not always account for:

1. bright band contamination,
2. hail contamination, and
3. inaccuracies due to radar outages.

Precipitation Processing Subsystem - Limitations

Summary - Algorithm Section

The Precipitation Detection Function determines a precipitation category.

The Preprocessing Algorithm performs quality control steps and constructs the hybrid scan.

The Rate Algorithm converts Reflectivity to rainfall rate.

The Accumulation Algorithm computes scan-to-scan and hourly accumulations.

The Adjustment Algorithm applies a multiplicative bias computed at AWIPS using rain gage to radar comparisons.

- One Hour Precipitation (OHP)
- Three Hour Precipitation (THP)
- Storm Total Precipitation (STP)
- User Selectable Precipitation (USP)
- One Hour Digital Precipitation Array (DPA)
- Supplemental Precipitation Data (SPD)

OHP product legend description: (Fig. 5-16)

- RPG ID: kxxx
- PRODUCT NAME: One Hour Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

OHP product annotations:

- VCP: 11, 21, 31 or 32
- MX: This is the maximum accumulation of precipitation on the product. The location of this value is unknown.
- BIAS/ERR: The multiplicative bias is displayed whether or not the Bias Flag at the RPG is set to True or False. (AWIPS 5.2.2)
- END: This is the date/time for the accumulations computed by the PPS for the particular volume scan.

Additional OHP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, with a range of 0.00 to 12.70 inches in multiples of 0.05 inch. Data level values are selected at the RPG HCI, and are under URC change authority.

Precipitation Products

One Hour Precipitation

Displays accumulations for the past hour.

Available from the first volume scan with detected rainfall (category 1 or 2).

Updated every volume scan after the first product - a moving one hour window of precipitation.

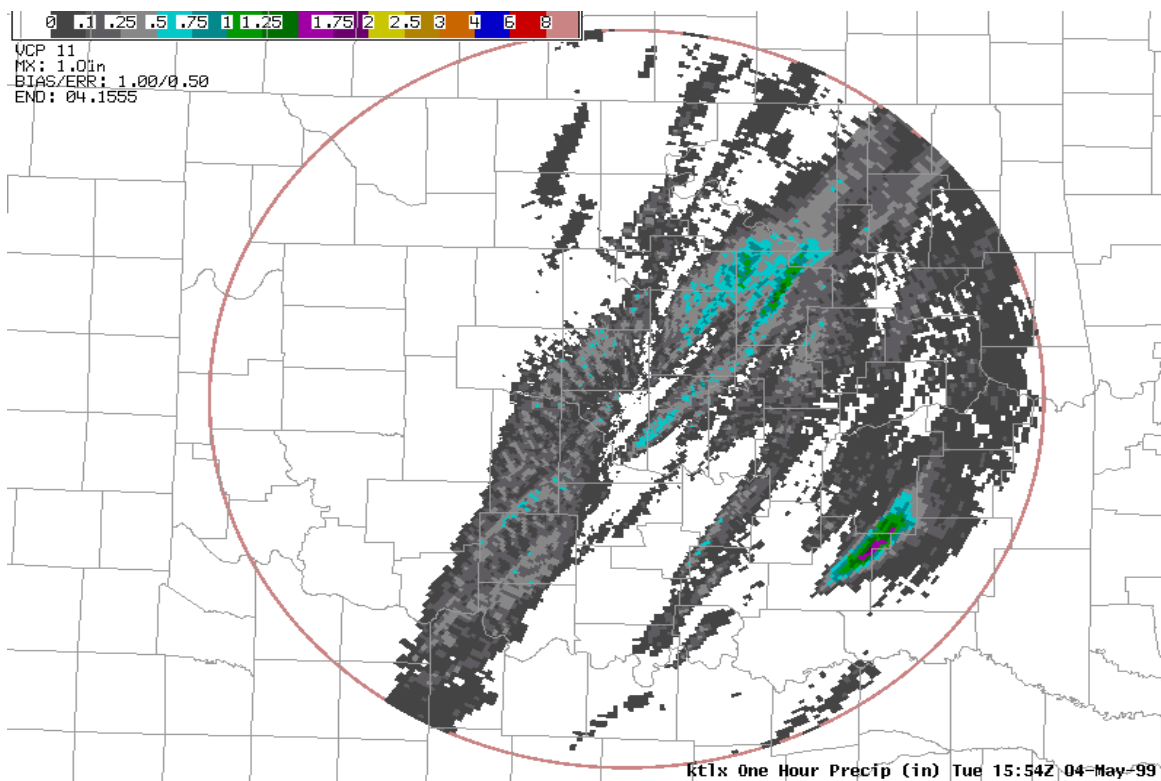


Figure 5-16. One Hour Precipitation

One Hour Precipitation - Applications

1. Assess rainfall accumulations for flash flood watches, warnings, and statements
2. Nowcasts and special weather statements
3. Time lapse can provide storm movement
4. Other water management applications

One Hour Precipitation - Limitations

1. After extended outages, first product will not be generated for 54 minutes
2. For some events, viewing interval too short

The screenshot shows a window titled 'Text 1: WSRHPTLX' with a menu bar (File, Edit, Options, Version, Tools, Scripts, Products) and a toolbar (Browser, Load cmd:, Enter Editor, Accum, Update Obs, Clear). The main text area displays the following parameters for the 1-HOUR PRECIPITATION ACCUMULATION product as of 07/22/99 14:16:

Parameter	Value	Unit
GAGE/RADAR BIAS ESTIMATE	1.0000	
ERROR VARIANCE OF BIAS ESTIMATE	0.5000	
PRODUCT ADJUSTED BY BIAS ESTIMATE?	NO	
MIN THRESHOLD DBZ FOR ISOLATED BIN TEST	18.00	DBZ
MAX DBZ ALLOWED BEFORE BEING LABELED AS OUTLIER	70.00	DBZ
TILT-TEST LOW REFLECTIVITY (DBZ) VALUE	1.00	DBZ
INNER RANGE LIMIT FOR TILT TEST	40.00	KM
OUTER RANGE LIMIT FOR TILT TEST	150.00	KM
MAX RANGE OF BI-SCAN MAXIMIZATION	230.00	KM
MIN PRECIP ECHO AREA NEEDED FOR TILT TEST IN LOW ELEV	600.00	KM**2
MIN AREA-WGTD-REFLECT. NEEDED FOR TILT TEST IN LOW ELEV	10.00	DBZ
MAX % AREA REDUCTION BETWEEN 2 LOWEST ELEVATIONS	75.00	%
REFLECT-TO-PRECIP RATE CONVERSION MULTIPLICATIVE COEFFICIENT	300.00	
REFLECT-TO-PRECIP RATE CONVERSION POWER COEFFICIENT	1.40	
MIN DBZ FOR CONVERTING TO PRECIP RATE (VIA TABLE LOOKUP)	0.00	DBZ
MAX DBZ FOR CONVERTING TO PRECIP RATE (VIA TABLE LOOKUP)	70.00	DBZ
MIN RANGE OF BI-SCAN MAXIMIZATION	180.00	KM
MAX STORM SPEED (M/SEC)	25.00	M/Sec
MAX SCAN-TO-SCAN TIME DIFFERENCE FOR TIME CONTINUITY TESTS	15.00	MINUTES
MIN PRECIP-AREA FOR PERFORMING TIME CONTINUITY TESTS	200.00	KM**2
RATE OF CHANGE: VOLUMETRIC PRECIP RATE, MIN ECHO AREA	24.00	1/Hr
RATE OF CHANGE: VOLUMETRIC PRECIP RATE, FULL ECHO UMBRELLA	13.20	1/Hr
MAX ECHO-AREA RATE OF CHANGE	200.00	KM**2/Hr
RANGE BEYOND WHICH TO APPLY RANGE-EFFECT CORRECTION	230.00	KM
1ST COEFFICIENT OF RANGE-EFFECT FUNCTION	0.00	DBR
2ND COEFFICIENT OF RANGE-EFFECT FUNCTION	1.00	
3RD COEFFICIENT OF RANGE-EFFECT FUNCTION	0.00	
MIN RATE SIGNIFYING PRECIPITATION	0.00	MM/Hr
MAX PRECIPITATION RATE	103.80	MM/Hr
REINITIALIZATION TIME LAPSE THRESHOLD (FOR ACCUM PROCESS)	60.00	MINUTES
MAX TIME DIFFERENCE BETWEEN SCANS FOR INTERPOLATION	30.00	MINUTES
MIN TIME NEEDED TO ACCUMULATE HOURLY TOTALS	54.00	MINUTES
THRESHOLD FOR HOURLY OUTLIER ACCUMULATION	400.00	MM
HOURLY GAGE ACCUMULATION SCAN ENDING TIME	0.00	MINUTES
MAX ACCUMULATION PER SCAN-TO-SCAN PERIOD	400.00	MM
MAX ACCUMULATION PER HOURLY PERIOD	800.00	MM
MINUTES AFTER CLOCK HOUR WHEN BIAS IS UPDATED	50.00	MINUTES
THRESHOLD # OF GAGE/RADAR PAIRS NEEDED TO CALCULATE BIAS	6.00	
RESET VALUE OF GAGE/RADAR BIAS ESTIMATE	1.00	
RESET VALUE OF ERROR VARIANCE OF BIAS ESTIMATE	0.50	
MAXIMUM ALLOWED ERROR VARIANCE OF BIAS ESTIMATE	0.80	
THRESHOLD TIME DIFFERENCE FOR ACCUMULATION GAGES	15.00	MINUTES
TIME DURING WHICH BIAS IS DRIFTED BACK TO RESET VALUE	12.00	HOURS
SYSTEM NOISE	0.05	
VARIANCE ADJUSTMENT FACTOR	0.50	
# OF STANDARD DEVIATIONS FOR DISCARDING GAGE/RADAR PAIRS	2.00	
MAX GAGE ACCUMULATION ALLOWED	400.00	MM
MIN HRLY GAGE OR RADAR ACCUM. NEEDED FOR BIAS CALCULATION	0.60	MM

Figure 5-17. OHP Alphanumeric Product (AWIPS Version 5.2.1 will change in AWIPS version 5.2.2)

THP product legend description: (Fig. 5-18)

- RPG ID: kxxx
- PRODUCT NAME: Three Hour Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

THP product annotations:

- VCP: 11, 21, 31 or 32
- MX: This is the maximum accumulation of precipitation on the product. The location of this value is unknown.

Three Hour Precipitation

- BIAS/ERR: Each hours multiplicative bias is displayed whether or not the Bias Flag at the RPG is set to True or False (AWIPS 5.2.2).
- END: This is the date/time for the accumulations computed by the PPS for the particular volume scan.

Additional THP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, with a range of 0.00 to 12.70 inches in multiples of 0.05 inch. Data level values are selected at the RPG HCI, and are under URC change authority.

Product accumulations updated once per hour, at the top of the hour

Requires two out of past three top of the hour accumulations (zero or nonzero) for product generation

Not recommended for RPS list

Three Hour Precipitation - Applications

1. Provides a longer viewing interval
2. For very long duration events, can be used with Storm Total Product for analysis
3. Corresponds to timing of flash flood guidance values

1. Product updated only once per hour

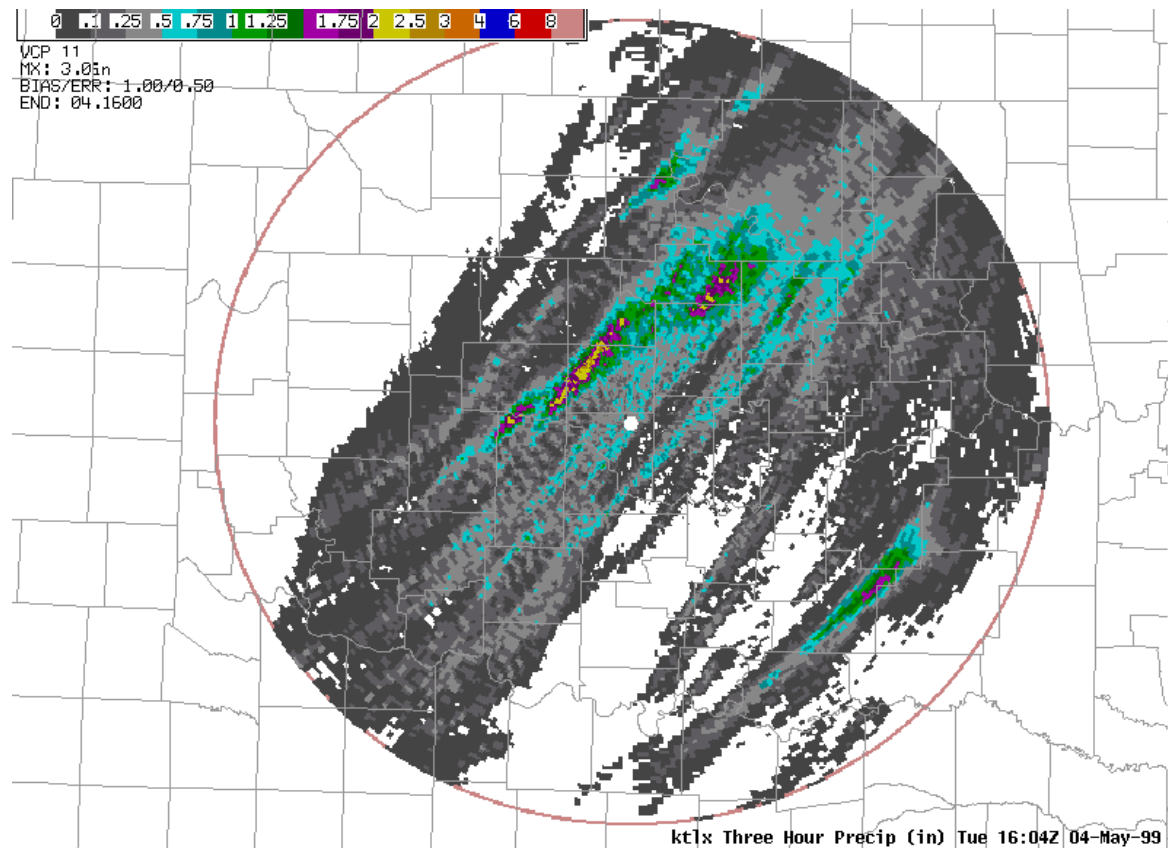
Three Hour Precipitation
- Limitations

Figure 5-18. Three Hour Precipitation

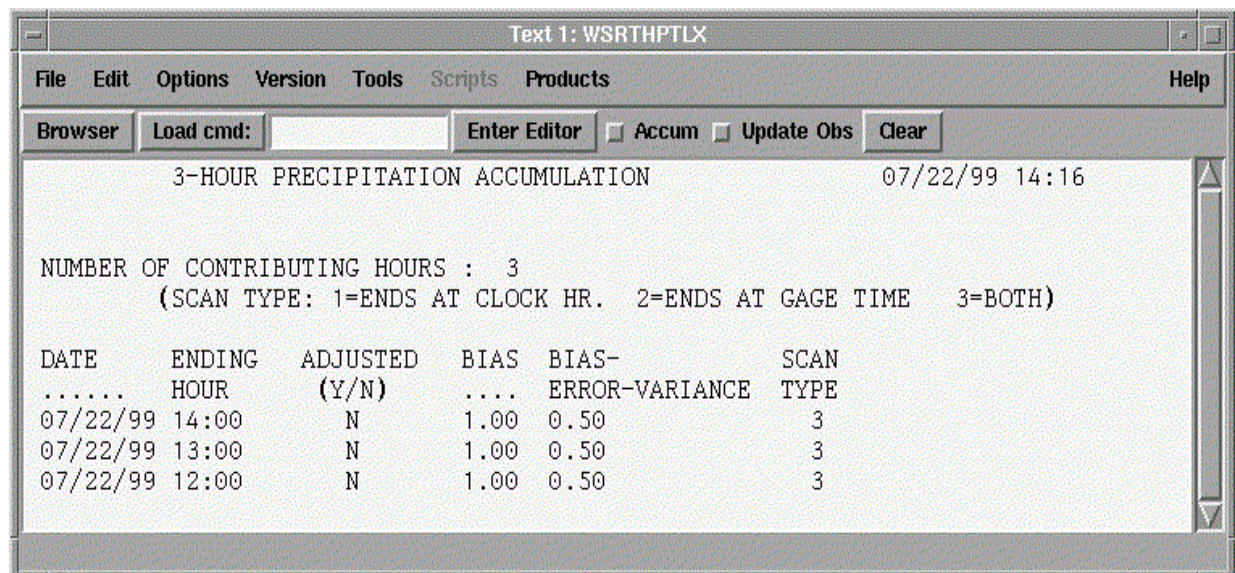


Figure 5-19. THP Alphanumeric Product (AWIPS Version 5.2.1 will change in AWIPS version 5.2.2)

Storm Total Precipitation

STP product legend description: (Fig. 5-20)

- RPG ID: kxxx
- PRODUCT NAME: Storm Total Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

STP product annotations:

- VCP: 11, 21, 31 or 32
- MX: This is the maximum accumulation of precipitation on the product. The location of this value is unknown.
- BIAS/ERR: The most recent multiplicative bias is displayed whether or not the Bias Flag at the RPG is set to True or False (AWIPS 5.2.2).
- BEG: Date/time of the first volume scan where category 1 or 2 was assigned.
- END: This the date/time for the accumulations computed by the PPS for the particular volume scan.

Additional STP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, with a range of 0.00 to 25.4 inches in multiples of 0.1 inch. Data level values selected at the RPG HCI (URC change authority).

Displays total rainfall accumulation

Available from the first volume scan with detected rainfall (category 1 or 2)

Updated every volume scan as long as the system remains in category 1 or 2

Accumulations reset to zero after one hour of no precipitation (category 0).

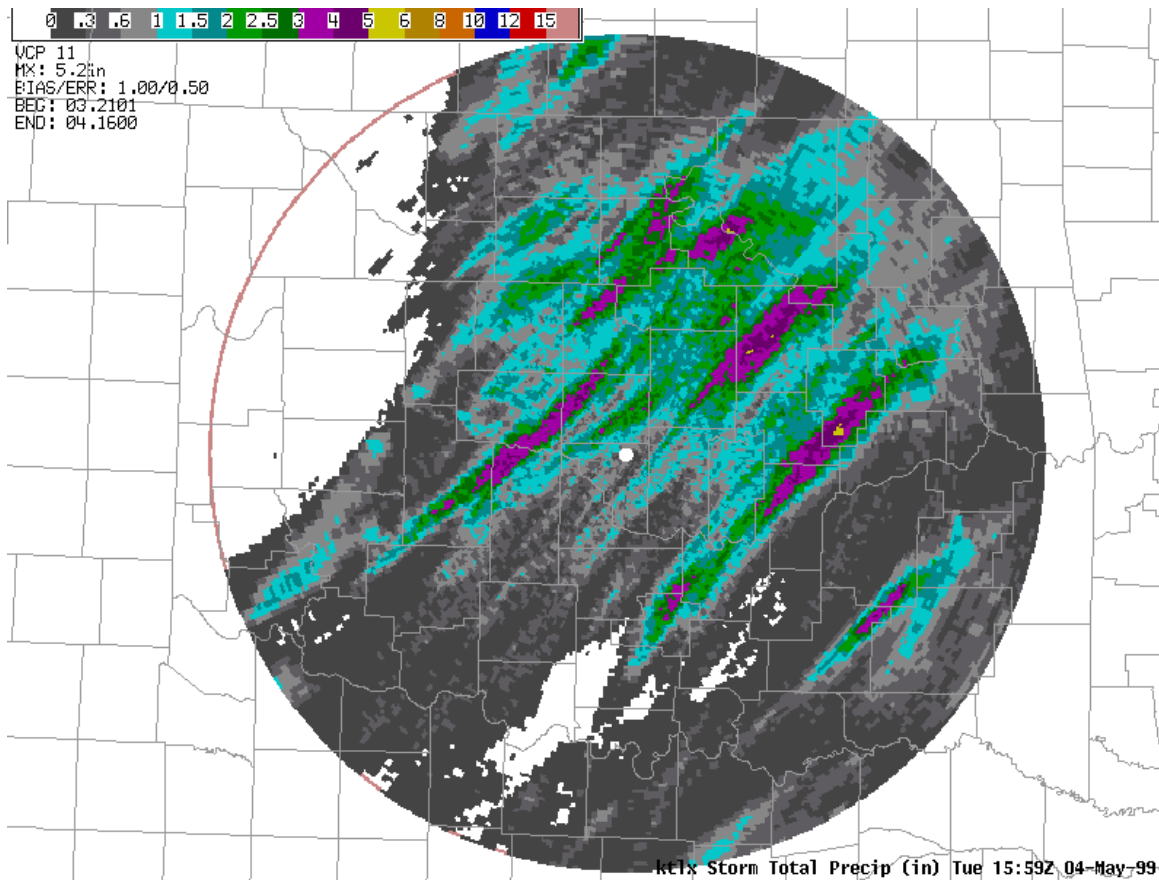


Figure 5-20. Storm Total Precipitation

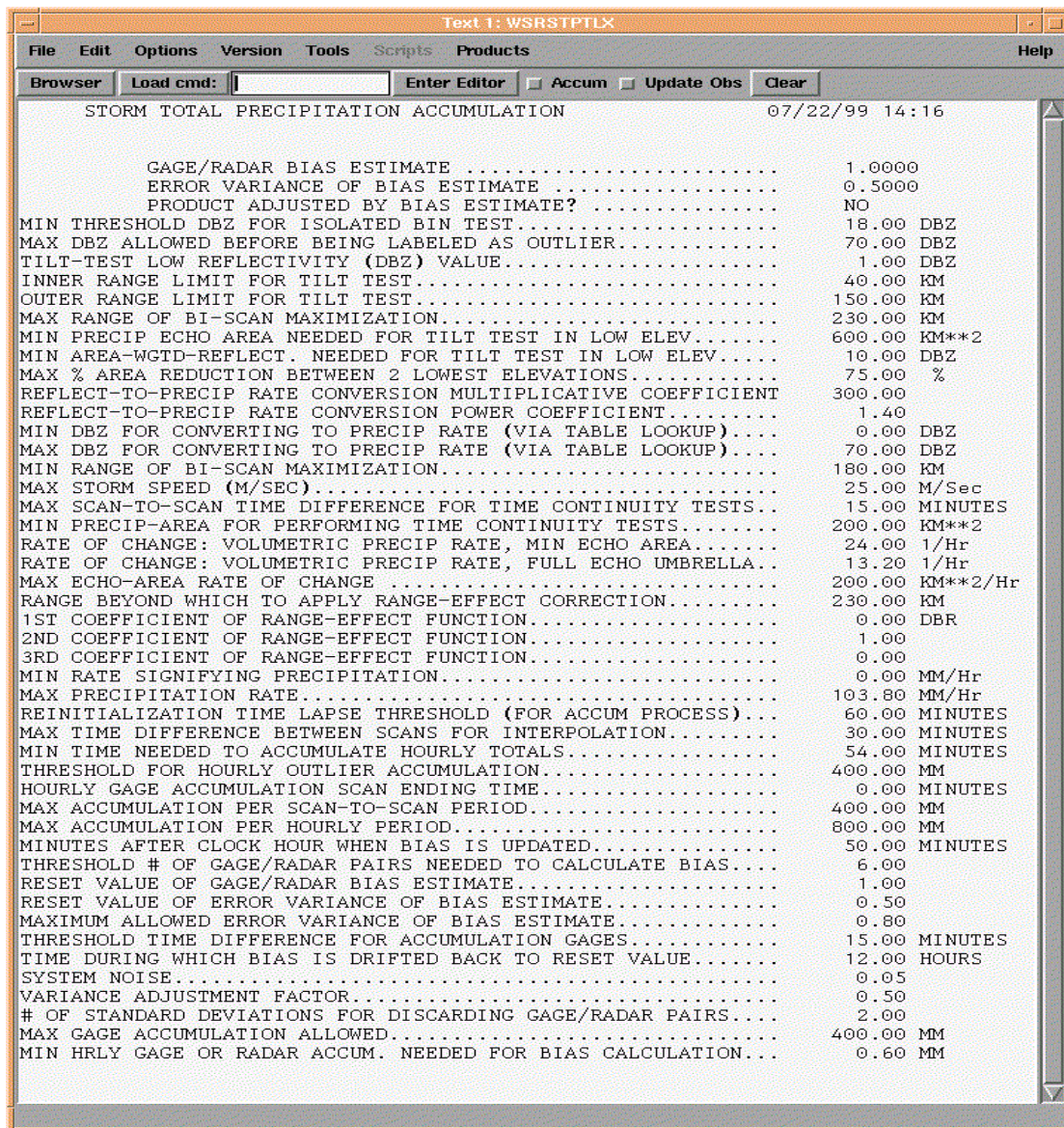
1. Monitor total precipitation accumulation
2. Estimate ground saturation and/or total basin runoff
3. Post storm analysis
4. Time lapse for tracking motion of storms

1. Can stay in category 1 or 2 for extended periods of time - can not manually reset to zero.

Storm Total Precipitation - Applications

Storm Total Precipitation - Limitations

2. Could include missing data without the knowledge of the operator.



The screenshot shows a text window titled "Text 1: WSRSTPTLX" with a menu bar (File, Edit, Options, Version, Tools, Scripts, Products) and a toolbar (Browser, Load cmd:, Enter Editor, Accum, Update Obs, Clear). The main text area displays the "STORM TOTAL PRECIPITATION ACCUMULATION" product for 07/22/99 14:16. The product lists various parameters and their values, including bias estimates, thresholds, and accumulation rates.

Parameter	Value	Unit
GAGE/RADAR BIAS ESTIMATE	1.0000	
ERROR VARIANCE OF BIAS ESTIMATE	0.5000	
PRODUCT ADJUSTED BY BIAS ESTIMATE?	NO	
MIN THRESHOLD DBZ FOR ISOLATED BIN TEST	18.00	DBZ
MAX DBZ ALLOWED BEFORE BEING LABELED AS OUTLIER	70.00	DBZ
TILT-TEST LOW REFLECTIVITY (DBZ) VALUE	1.00	DBZ
INNER RANGE LIMIT FOR TILT TEST	40.00	KM
OUTER RANGE LIMIT FOR TILT TEST	150.00	KM
MAX RANGE OF BI-SCAN MAXIMIZATION	230.00	KM
MIN PRECIP ECHO AREA NEEDED FOR TILT TEST IN LOW ELEV	600.00	KM**2
MIN AREA-WGTD-REFLECT. NEEDED FOR TILT TEST IN LOW ELEV	10.00	DBZ
MAX % AREA REDUCTION BETWEEN 2 LOWEST ELEVATIONS	75.00	%
REFLECT-TO-PRECIP RATE CONVERSION MULTIPLICATIVE COEFFICIENT	300.00	
REFLECT-TO-PRECIP RATE CONVERSION POWER COEFFICIENT	1.40	
MIN DBZ FOR CONVERTING TO PRECIP RATE (VIA TABLE LOOKUP)	0.00	DBZ
MAX DBZ FOR CONVERTING TO PRECIP RATE (VIA TABLE LOOKUP)	70.00	DBZ
MIN RANGE OF BI-SCAN MAXIMIZATION	180.00	KM
MAX STORM SPEED (M/SEC)	25.00	M/Sec
MAX SCAN-TO-SCAN TIME DIFFERENCE FOR TIME CONTINUITY TESTS	15.00	MINUTES
MIN PRECIP-AREA FOR PERFORMING TIME CONTINUITY TESTS	200.00	KM**2
RATE OF CHANGE: VOLUMETRIC PRECIP RATE, MIN ECHO AREA	24.00	1/Hr
RATE OF CHANGE: VOLUMETRIC PRECIP RATE, FULL ECHO UMBRELLA	13.20	1/Hr
MAX ECHO-AREA RATE OF CHANGE	200.00	KM**2/Hr
RANGE BEYOND WHICH TO APPLY RANGE-EFFECT CORRECTION	230.00	KM
1ST COEFFICIENT OF RANGE-EFFECT FUNCTION	0.00	DBR
2ND COEFFICIENT OF RANGE-EFFECT FUNCTION	1.00	
3RD COEFFICIENT OF RANGE-EFFECT FUNCTION	0.00	
MIN RATE SIGNIFYING PRECIPITATION	0.00	MM/Hr
MAX PRECIPITATION RATE	103.80	MM/Hr
REINITIALIZATION TIME LAPSE THRESHOLD (FOR ACCUM PROCESS)	60.00	MINUTES
MAX TIME DIFFERENCE BETWEEN SCANS FOR INTERPOLATION	30.00	MINUTES
MIN TIME NEEDED TO ACCUMULATE HOURLY TOTALS	54.00	MINUTES
THRESHOLD FOR HOURLY OUTLIER ACCUMULATION	400.00	MM
HOURLY GAGE ACCUMULATION SCAN ENDING TIME	0.00	MINUTES
MAX ACCUMULATION PER SCAN-TO-SCAN PERIOD	400.00	MM
MAX ACCUMULATION PER HOURLY PERIOD	800.00	MM
MINUTES AFTER CLOCK HOUR WHEN BIAS IS UPDATED	50.00	MINUTES
THRESHOLD # OF GAGE/RADAR PAIRS NEEDED TO CALCULATE BIAS	6.00	
RESET VALUE OF GAGE/RADAR BIAS ESTIMATE	1.00	
RESET VALUE OF ERROR VARIANCE OF BIAS ESTIMATE	0.50	
MAXIMUM ALLOWED ERROR VARIANCE OF BIAS ESTIMATE	0.80	
THRESHOLD TIME DIFFERENCE FOR ACCUMULATION GAGES	15.00	MINUTES
TIME DURING WHICH BIAS IS DRIFTED BACK TO RESET VALUE	12.00	HOURS
SYSTEM NOISE	0.05	
VARIANCE ADJUSTMENT FACTOR	0.50	
# OF STANDARD DEVIATIONS FOR DISCARDING GAGE/RADAR PAIRS	2.00	
MAX GAGE ACCUMULATION ALLOWED	400.00	MM
MIN HRLY GAGE OR RADAR ACCUM. NEEDED FOR BIAS CALCULATION	0.60	MM

Figure 5-21. STP Alphanumeric Product (AWIPS Version 5.2.1 will change in AWIPS version 5.2.2)

USP product legend description: (Fig. 5-22)

- RPG ID: kxxx
- PRODUCT NAME: User Def Total Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

USP product annotations:

- VCP: 11, 21, 31 or 32

Additional USP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, OHP/THP data levels or STP data levels used

User Selectable Precipitation

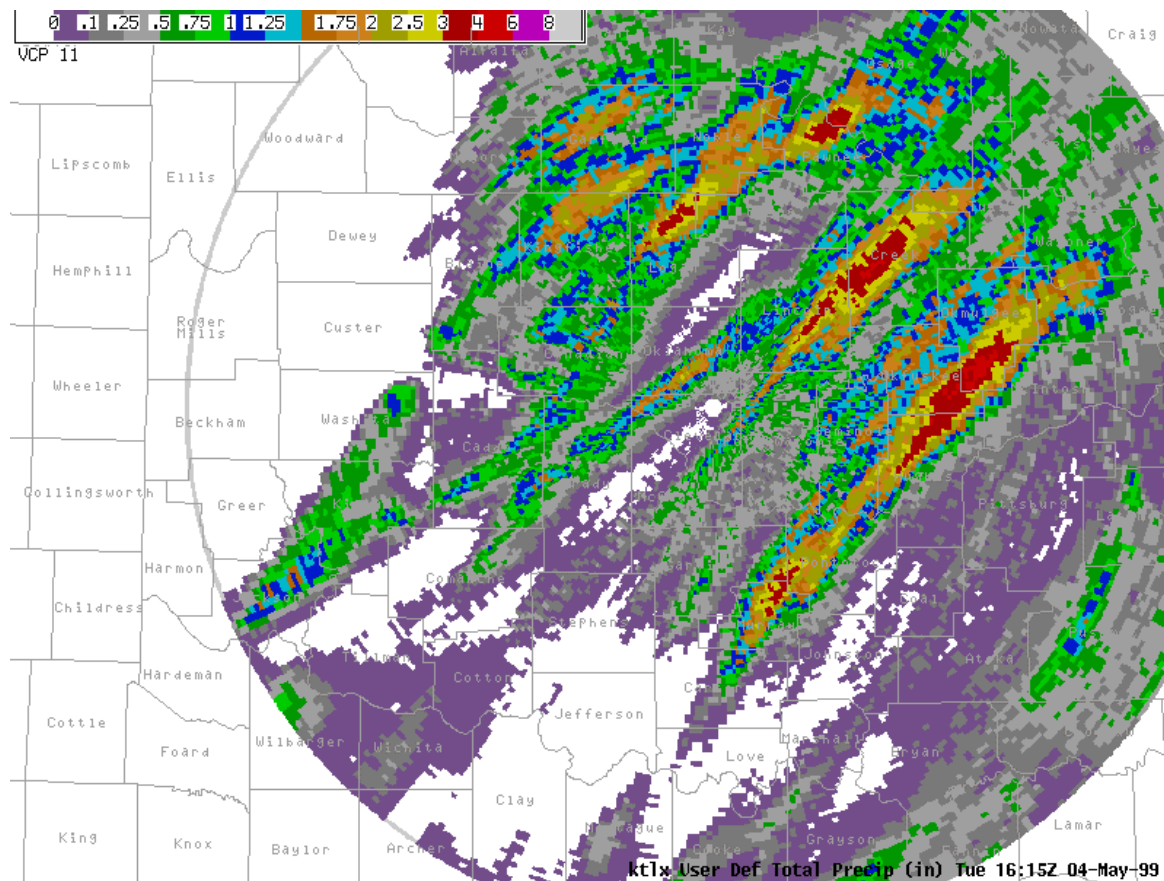


Figure 5-22. User Selectable Precipitation

dependent on the magnitude of accumulations
Displays precipitation accumulations for a user specified period of time using top of the hour accumulations. The past 30 hours of top of the hour accumulations are available.

User selects duration (up to 24 hours) and end time

- Default USP generated for 24 hours ending at 12Z.

Figure 5-23. One Time Request

User Selectable Precipitation - Applications

1. Flexible time interval to meet varying weather situations
2. In addition to the 24 hour default USP, any others generated for dedicated users are available by OTR to dial-up users.

User Selectable Precipitation - Limitations

1. USP accumulations are updated only at the top of the hour

2. Product may contain missing data. At least two thirds of the specified hourly accumulations must be available for product generation.
3. Since the USP is a customized product, only 10 can be generated per volume scan.

The RPG produces another hourly product, called the One Hour Digital Precipitation Array (DPA). Instead of the 1.1 nm x 1° polar grid, the DPA has a rectangular grid of about 2.2 x 2.2 nm. Instead of 16 data levels, the DPA has 256 data levels. Similar to the One Hour Precipitation Product, the DPA has a moving one hour of accumulation (scan-to-scan accumulations). The product is used by the RFCs to generate precipitation input for the NWS River Forecast System (NWSRFS), and the AWIPS Multisensor Precipitation Estimator (MPE) used for the bias calculation. The rectangular grid allows for mosaicking the numerous WSR-88Ds within the RFC's area of responsibility.

The Supplemental Precipitation Data is an **alpha-numeric only** product received at the AWIPS workstation like any other product. (Fig. 5-24)

Output on PPS algorithms (each volume scan):

1. current bias value
2. information on gage-radar pairs
3. number of isolated bins and outliers that are corrected
4. percent echo reduction from 0.5° to 1.5° from the tilt test
5. ratio of range bins chosen from the 1.5° vs 0.5° slices from bi-scan maximization periods of missing data

One Hour Digital Precipitation Array (DPA)

Supplemental Precipitation Data (SPD)

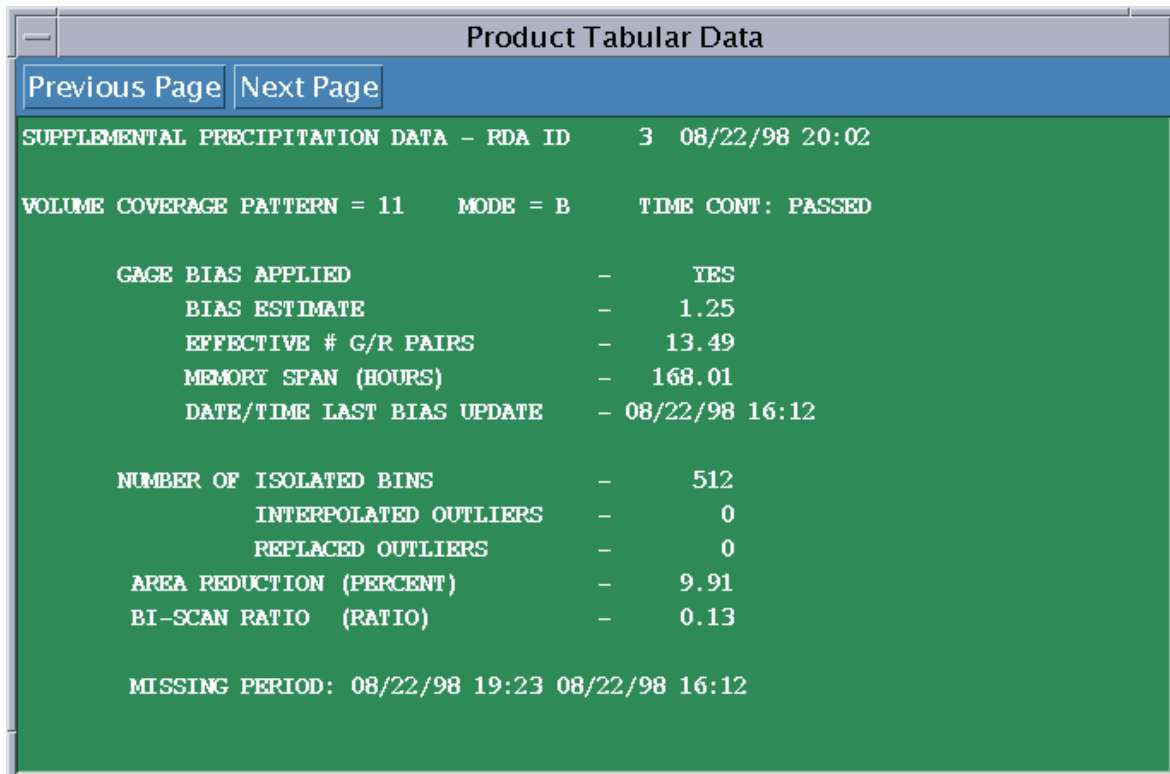


Figure 5-24. Supplemental Precipitation Data (AWIPS 5.2.2 Version)

Precipitation Data Levels

Introduction

Data levels on the One Hour, Three Hour, and Storm Total Precipitation products may be edited at the RPG HCI in accordance with policies set forth by your local Unit Radar Committee.

Why modify Precipitation Data Levels?

Data level changes depend on the location of the radar, topography and previous weather in the area of concern. For example, data levels in parts of the Western states may need more detail in the lower end of the scale than areas of the Gulf Coast states.

One/Three Hour Precipitation Products

The One/Three Hour Precipitation product has 16 accumulation data levels corresponding to each of the 16 color codes represented on the product.

The first data level is non-modifiable and has the acronym ND (No Data) for areas with no accumulation or areas outside the product coverage area.

The second data level is also non-modifiable and is given a value of > 0.00 . This is color code 2 and displays regions with accumulations greater than zero but less than the level set for code 3.

The remaining levels, codes 3 to 16, are modifiable by the operator and range from 0.05 through 12.70 inches in multiples of 0.05 inch.

The Storm Total Precipitation product also has 16 data levels and is modified the same as the One/Three Hour product. The only difference is the range of the data levels.

Storm Total Precipitation Product

Once again levels 1 and 2 are non-modifiable. Levels 3 to 16 are modifiable and range from 0.1 through 25.4 inches in multiples of 0.1 inch.

Click on User - Products - Selectable Parameters - OHP/THP Data Levels (See Fig. 5-25.)

Editing OHP/THP Data Levels at RPG HCI

The screenshot shows a software window titled "Edit Selectable Product Parameters". At the top, there are buttons for "Close", "Save", "Undo", and "Baseline: Restore Update". Below these are several radio button options for product categories: "Contour Product", "Cell Product", "Layer Product", "OHP/THP Data Levels" (which is selected), "RCM Product", "RCM Reflectivity Data Levels", "STP Data Levels", "VAD and RCM Heights", and "Velocity Data Levels".

The main section is titled "OHP/THP Data Levels". On the left, there is a text block with instructions: "-----INSTRUCTIONS-----
Permissible value range is from 0.0 to 12.7 inches in multiples of 0.05. The value entered represents the minimum value of the data level."

On the right, there are two columns of data levels, each with a "Code", a comparison operator, and a "Current (inches)" value:

Code	Operator	Current (inches)
1		ND
2	>	0.00
3	>=	0.10
4	>=	0.25
5	>=	0.50
6	>=	0.75
7	>=	1.00
8	>=	1.25
9	>=	1.50
10	>=	1.75
11	>=	2.00
12	>=	2.50
13	>=	3.00
14	>=	4.00
15	>=	6.00
16	>=	8.00

Figure 5-25. Edit screen for the OHP/THP product data levels at the RPG HCI.

Edit Selectable Product Parameters

CloseSaveUndo

Baseline: RestoreUpdate

☐ Contour Product

☐ Cell Product

☐ Layer Product

Category:

☐ OHP/THP Data Levels

☐ RCM Product

☐ RCM Reflectivity Data Levels

☒ STP Data Levels

☐ VAD and RCM Heights

☐ Velocity Data Levels

STP Data Levels

-----INSTRUCTIONS-----

Permissible value range is from 0.0 to 25.4 inches in multiples of 0.1. The value entered represents the minimum value of the data level.

Code	Current (inches)	Code	Current (inches)
1	ND	9	>= 3.0
2	> 0.0	10	>= 4.0
3	>= 0.3	11	>= 5.0
4	>= 0.6	12	>= 6.0
5	>= 1.0	13	>= 8.0
6	>= 1.5	14	>= 10.0
7	>= 2.0	15	>= 12.0
8	>= 2.5	16	>= 15.0

Figure 5-26. Edit screen for the Storm Total Precipitation product data levels on the RPG HCI.

Editing STP Data Levels at
RPG HCI

Click on User - Products - Selectable Parameters
STP Data Levels (See Fig. 5-26.).

Summary - Precipitation Products

Graphical and/or Alphanumeric Products at the AWIPS Workstation

1. Hybrid Scan Reflectivity (HSR)
2. Digital Hybrid Scan Reflectivity (DHR)
3. One Hour Precipitation (OHP)
4. Three Hour Precipitation (THP)
5. Storm Total Precipitation (STP)
6. User Selectable Precipitation (USP)
7. Digital Precipitation Array (DPA)
8. Supplemental Precipitation Data (SPD)

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Worksheet
Storm Cell Algorithms and Products

The following pertain to the SCIT algorithm and products. Answer them if you desire a little extra practice. The answers are included at the end of the worksheet.

1. Which VCP will generally give more representative output of derived products, especially within 60nm of the radar?
2. Who has the authority to make changes to the 7 reflectivity thresholds used to identify storm cells in the SCIT algorithms?
3.
 - a. What environmental data must be set for the Hail Detection Algorithm to be representative?
 - b. How often should this information be updated?
 - c. Whose responsibility is it to do so?
4. What product must be in the data base in order to generate a Cell Trends Display?
5. True/False The Cell Trends Display can be placed on the RPS List and archived.
6. The bases of a storm approaching from the northwest appear (on the Cell Trends display) to have been decreasing with time. What non-meteorological reason could there be to explain this display?

Worksheet

Storm Cell Algorithms and Products....ANSWERS!!

1. Which VCP will generally give more representative output of derived products, especially within 60nm of the radar?

VCP 11 - Less gaps

2. Who has the authority to make changes to the 7 reflectivity thresholds used to identify storm cells in the SCIT algorithms?

ROC

3.
 - a. What environmental data must be set for the Hail Detection Algorithm to be representative?
Heights of the 0 degree and -20 degree isotherms.
 - b. How often should this information be updated?
At least twice a day, or as often as necessary to reflect environmental conditions.
 - c. Whose responsibility is it to do so?
The local office with ORPG HCI control.
4. What product must be in the data base in order to generate a Cell Trends Display?
Storm Structure (SS)
5. True/False The Cell Trends Display can be placed on the RPS List and archived.
FALSE - The Trends Display is NOT a product and must be regenerated each time it is desired for viewing. The "product" from which it is generated is the Storm Structure product.
6. The bases of a storm approaching from the northwest appear (on the Cell Trends display) to have been decreasing with time. What non-meteorological reason could there be to explain this display?
Bases may be detected on the lowest slice. If the storm is approaching the radar, the bases will appear to lower since the height of the 0.5° slice decreases as you get closer to the radar.

8/02

Review Exercises

SCIT Products

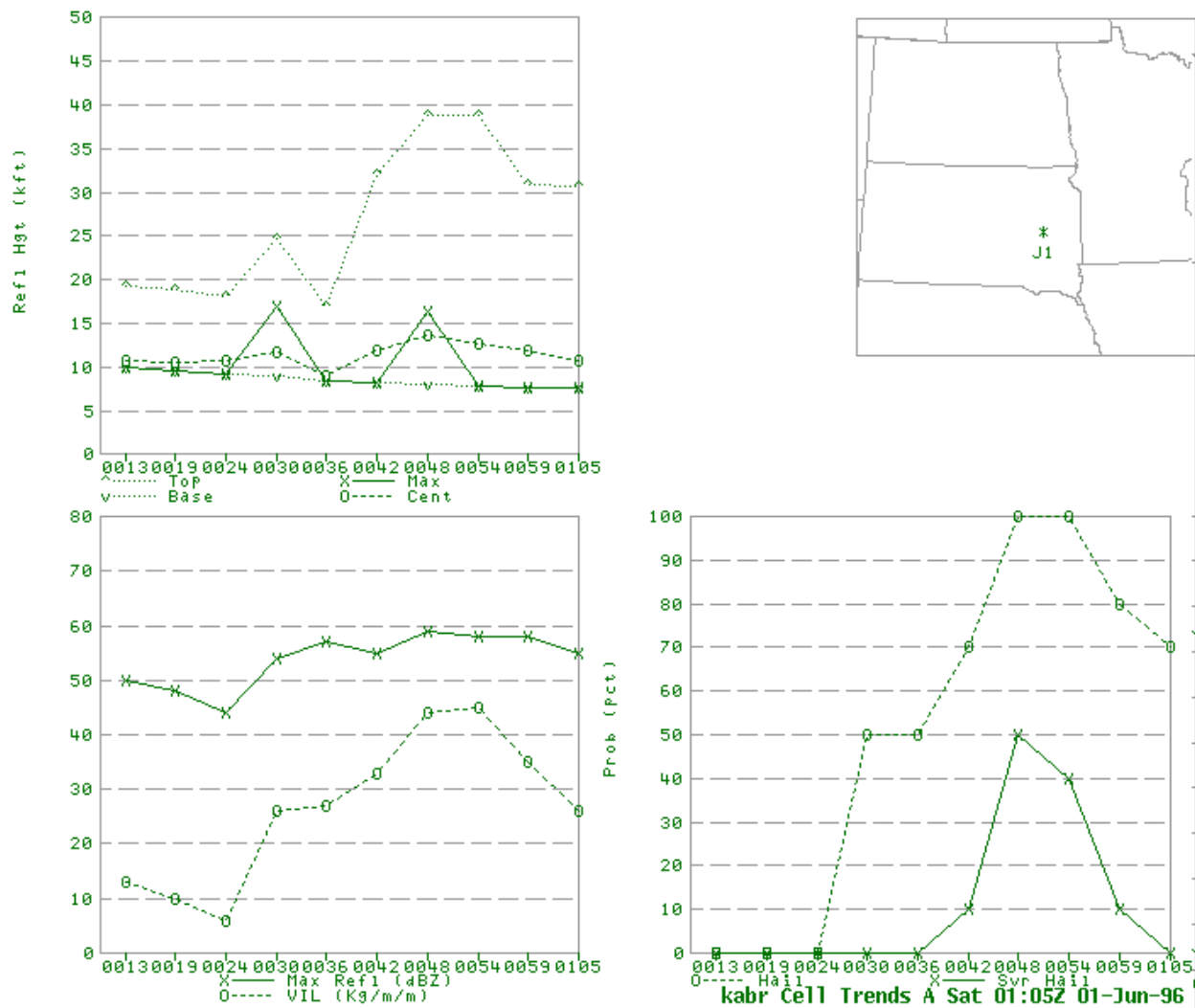
Instructions: Select the most correct answer. Question 5 requires the figure provided.

1. Which of the following statements about the Storm Track Information Product is **true**?
 - a) Right turning storms will be indicated by a curved forecast track.
 - b) Past positions will be plotted in volume scan intervals.
 - c) The movement of hurricanes will be well tracked.
2. Which of the following statements is **true** about the Storm Track Information Product?
 - a) The product can only be used as an overlay on volume products.
 - b) Lines of storms will usually treated as a single cell.
 - c) Storm cells in close proximity to one another may have erroneous attributes.
3. True/False The Hail product no longer takes into account the environment.
4. A forecast office observes thunderstorms ahead of a cold front in the warm sector, and other ones deep in the cold air behind the front. The Hail Temperatures Data was input during the morning before the front went through. What will the Hail Product likely do with the storms in the **cold sector**?
 - a) Overestimate the actual hail size.
 - b) Underestimate the actual hail size.
 - c) Have no effect on the estimated hail size.

Question 5 will use the Cell Trends Display figure

5. What is the likely reason that the bases appear to lower with time?
- The storm is moving away from the radar and being sampled poorly.
 - The bases are likely on the 0.5 degree slice which gives them the appearance of lowering as the storm approaches the RDA.
 - The base of the storm is likely lowering because the centroid is lowering with time.

Review Exercises



SCIT Products

*****ANSWERS*****

Be sure and look at all answers if you are not sure why they are right or wrong.

1. Which of the following statements about the Storm Track Information Product is true?
 - a) Right turning storms will be indicated by a curved forecast track.
No. Forecast tracks will always be indicated with a straight line. If a storm's past track indicates it is turning, the user should mentally adjust the forecast positions to account for this.
 - b) Past positions will be plotted in volume scan intervals.
Yes. Up to 10 volume scans of past positions will be displayed. A storm whose centroid is deviating will have this represented in the past tracks.
 - c) The movement of hurricanes will be well tracked
While individual cells within the hurricane may be tracked pretty well, the overall movement of the hurricane will not be.
2. Which of the following statements is true about the Storm Track Information Product?
 - a) The product can only be used as an overlay on volume products.
No. Actually you can overlay the STI on any other geographic product (volume or base). The problem is that they must be from the same volume scan, i.e the times must match. This is why when you get a newly arriving Base Reflectivity, for example, and try to overlay the STI on it, it will not display (it has not been generated yet for that volume scan).
 - b) Lines of storms will usually treated as a single cell.
No. The SCIT algorithm will define areas of higher reflectivities within the line as individual cells. It will also usually break apart large core storms as they get closer to the RDA.
 - c) Storm cells in close proximity to one another may have erroneous attributes..
Yes! Because the SCIT algorithm tries to separate out individual cells in a cluster of cells, it will occasionally mismatch low and higher level components. For instance, a cell which previously was identified to 40Kft may have its top half assigned to a nearby cell in the next volume scan. Imagine what this would do to the Cell Trend information for both of these cells!
3. True/False The Hail product no longer takes into account the environment.
The answer is False! It does attempt to account for changes in the environment by using the height of the 0 degree and -20 degree isotherms (input at the ORPG

HCI).

4. A forecast office observes thunderstorms ahead of a cold front in the warm sector, and other ones deep in the cold air behind the front. The Hail Temperatures Data was input during the morning before the front went through. What will the Hail Product likely do with the storms in the **cold sector**?
- a) Overestimate the actual hail size.
No - just the opposite. Imagine the freezing level was at 12Kft in the morning, and is now down to 4Kft. The height of the -20 degree isotherm has also dropped a few thousand feet. The algorithm checks to see how far above the freezing level (and how far above the height of the -20 degree isotherm) the 40-50dBZ core is. It will obviously underestimate these depths if still using the higher altitudes from the morning sounding. This will lead to an underestimation of the hail size in this cold sector.
 - b) Underestimate the actual hail size.
Yes! Imagine the freezing level was at 12Kft in the morning, and is now down to 4Kft. The height of the -20 degree isotherm has also dropped a few thousand feet. The algorithm checks to see how far above the freezing level (and how far above the height of the -20 degree isotherm) the 40-50dBZ core is. It will obviously underestimate these depths if still using the higher altitudes from the morning sounding. This will lead to an underestimation of the hail size in this cold sector.
 - c) Have no effect on the estimated hail size.
It will likely have an effect, which could be substantial depending on how drastic a change has taken place. Imagine the freezing level was at 12Kft in the morning, and is now down to 4Kft. The height of the -20 degree isotherm has also dropped a few thousand feet. The algorithm checks to see how far above the freezing level (and how far above the height of the -20 degree isotherm) the 40-50dBZ core is. It will obviously underestimate these depths if still using the higher altitudes from the morning sounding. This will lead to an underestimation of the hail size in this cold sector.

Question 5 uses the Cell Trends Display figure.

5. What is the likely reason that the bases appear to lower with time?
- a) The storm is moving away from the radar and being sampled poorly
While this is possible, it is not indicated in this image (if the storm were moving further from the RDA, the bases would appear to be higher with time).
 - b) The bases are likely on the 0.5 degree slice which gives them the appearance of lowering as the storm approaches the RDA.

This is the most likely answer. The gradual lowering with time may actually be happening, but is likely an artifact of sampling. If the 0.5 degree slice samples a storm, and the storm is approaching the radar, the height of the bases will appear to lower (since the altitude of the beam centerline of any slice is decreasing the closer you get to the radar.)

- c) The base of the storm is likely lowering because the centroid is lowering with time. **While this is possible, there is no correlation that states when the centroid lowers, the base lowers. In this example, the centroid is actually fluctuating, while the bases appear to consistently decrease.**

8/02

Worksheet
Reflectivity Derived Products

The following questions pertain to Reflectivity Derived Products. Answer them if you desire a little extra practice. The answers are included at the end of the worksheet.

1. A thunderstorm moving at 45 mph has a VIL considerably lower than the threshold you estimated earlier in the day. You get reports of quarter size hail. Can you explain? **Note: The airmass has not changed appreciably.**
2. A storm which you have classified as a “mini supercell” is currently producing a tornado. The VILs with it are less than 20kg/m². Why?
3. The Cell-Based VIL (associated with the “main” cell of a very large storm complex 20 miles away from the RDA) has apparently decreased dramatically this volume scan. At the same time, the Grid VIL has remained high and fairly constant. Any explanation?
4. In what instances might the Cell-Based VIL be higher than the Grid VIL for a particular storm?
5. How are critical VIL thresholds (values which correlate with 3/4 inch hail) established on a given day?
6. Why are the VIL values sometimes unreliable beyond 100nm?
7. A member of the local media calls you up to say he’s using the information on the Composite Reflectivity attribute table to locate a TVS listed there. However, at the AZ/RAN listed, he sees no evidence of a circulation. Is this TVS a false alarm?

Distance Learning Operations Course

8. What two radar limitations cause the bases and tops of echoes in cross sections to be truncated?
9. While cross sections can show storm structure and the depth of the reflectivity core, why will they likely not be the primary tool for investigating storms in real time?
10. Why would you not expect to see hook echoes on a Composite Reflectivity?
11. Why are the tops on the Echo Tops Product frequently displayed with a circular stair-stepped appearance?
12. Why do the tops on the Echo Tops product vary from the storm cell tops from the SCIT Algorithm (displayed on the Combined Attribute Table)?

Worksheet

Reflectivity Derived Products...ANSWERS!

1. A thunderstorm moving at 45 mph has a VIL considerably lower than the threshold you estimated earlier in the day. You get reports of quarter size hail. Can you explain? **Note: The airmass has not changed appreciably.**
The speed is causing reflectivity on higher tilts to be spread to adjacent grid boxes. This will be more pronounced in VCP 21 in faster moving storms since it takes a minute longer.
2. A storm which you have classified as a “mini supercell” is currently producing a tornado. The VILs with it are less than 20kg/m². Why?
A mini supercell is by definition low topped. The reflectivity core does not have great vertical extent. VIL (being a measure of the vertical extent of reflectivity) will be correspondingly low.
3. The Cell-Based VIL (associated with the “main” cell of a very large storm complex 20 miles from the RDA) has apparently decreased dramatically this volume scan. At the same time, the Grid VIL has remained high and fairly constant. Any explanation?
Often large storms will have several “cells” identified with them. This may cause components to be mis-assigned when these cells are in close proximity. In this case, an adjacent cell probably got the components previously assigned to the “main” cell. The result may be that cell based output may be adversely affected.
4. In what instances might the Cell-Based VIL be higher than the Grid VIL for a particular storm?
If a storm is fast moving or strongly tilted, it can retain more of its definition in the Cell-Based VIL (assuming it has been correctly identified by the algorithm) while in the Grid VIL, upper and lower cores may end up in adjacent grid boxes.
5. How are critical VIL thresholds (values which correlate with 3/4 inch hail) established on a given day?
The operator must consider the environment, make an estimate, and then verify it with ground truth. There may be other ways (possibly relating the Wet-Bulb Zero or using VIL Density), but they too should use ground truth to verify.
6. Why are the VIL values sometimes unreliable beyond 100nm?
The algorithm assumes the dBZ values at 0.5 degrees extend to the surface. This may cause mid and high topped storms to have overestimated VILs, and low-topped convection to have underestimated VILs.

7. A member of the local media calls you up to say he's using the information on the Composite Reflectivity attribute table to locate a TVS listed there. However, at the AZ/RAN listed, he sees no evidence of a circulation. Is this TVS a false alarm?
- The azimuth and range listed on the Composite Reflectivity Combined Attribute Table (to which NIDS users do have access), is that of the *storm cell* whose ID is listed on the table. That AZ/RAN, which comes from the SCIT algorithm, is the location of the cell's 3-D center of mass, not the location of any TVS or MESO which may be associated with the storm. In order to locate the AZ/RAN of any TVSs (and there may be more than one) which are "associated" with this storm, one must look at the TVS product (which NIDS users do NOT have access to.) In this case, all anyone can tell by looking at the CR attribute table is that there is at least 1 TVS detected during this volume scan that was given the ID of the storm listed.**
8. What two radar limitations cause the bases and tops of echoes in cross sections to be truncated?
- Bases will be truncated due to the radar horizon effects.
Tops will be truncated due to scan strategy effects.**
9. While cross sections can show storm structure and the depth of the reflectivity core, why will they likely not be the *primary* tool for investigating storms in real time?
- It can be hard to get placement just right. It also takes time and is always from the previous volume scan.**
10. Why would you not expect to see hook echoes on a Composite Reflectivity?
- Echo overhang will usually obliterate it.**
11. Why are the tops on the Echo Tops Product frequently displayed with a circular stair-stepped appearance?
- It uses the height of the beam center point. Because the beam is so large at far ranges, the altitude change from one slice to the next adjacent slice can be much more dramatic. Also it uses 5kft increments.**
12. Why do the tops on the Echo Tops product vary from the storm cell tops from the SCIT Algorithm (displayed on the Combined Attribute Table)?
- The ET product uses the height of the 18.3 dBZ echo.
The Storm/Cell Top uses the height of the highest component (at least 30 dBZ).**

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Review Exercises

Reflectivity Derived Products

Instructions: Select the most correct answer. Questions 8-11 require the figures provided.

1. True or False Cell-Based VIL will *usually* be more accurate than Grid VIL for a fast moving storm.
2. Which of the following statements about the Composite Reflectivity product is true?
 - a) The height of the maximum reflectivity for each resolution grid box is known.
 - b) The product is useful for locating hook echoes, when present with a storm.
 - c) Echo aloft can not be discriminated from precipitation reaching the surface.
3. The Echo Tops product will be useful for distinguishing:
 - a) between liquid and frozen precipitation.
 - b) the height of higher dBZ's.
 - c) AP from precipitation echoes.
4. True or False The base altitude for the LRM Low Layer product must be no less than 6 thousand feet MSL.
5. When examining a thunderstorm, one strength of the Reflectivity Cross Section product is:
 - a) to estimate storm top divergence.
 - b) the combined attribute table is available.
 - c) to evaluate the height of higher dBZ's.
6. The Layer Composite Reflectivity Maximum *mid-level* product will often be useful in determining:
 - a) The location of BWERs when present.
 - b) echo development aloft.
 - c) the max dBZ in a storm.

7. Which of the following products may be effective for detecting storms with $\geq 3/4$ inch hail? (More than one answer possible).
- a) Hail Index
 - b) Echo Tops
 - c) Vertically Integrated Liquid
 - d) Reflectivity Cross Section
 - e) Layer Composite Reflectivity Maximum
 - f) Composite Reflectivity
 - g) Storm Track

Questions 8-11 use the figures provided.

8. **True or False** A bounded weak echo region is located on the west side of the storm depicted in the cross section.

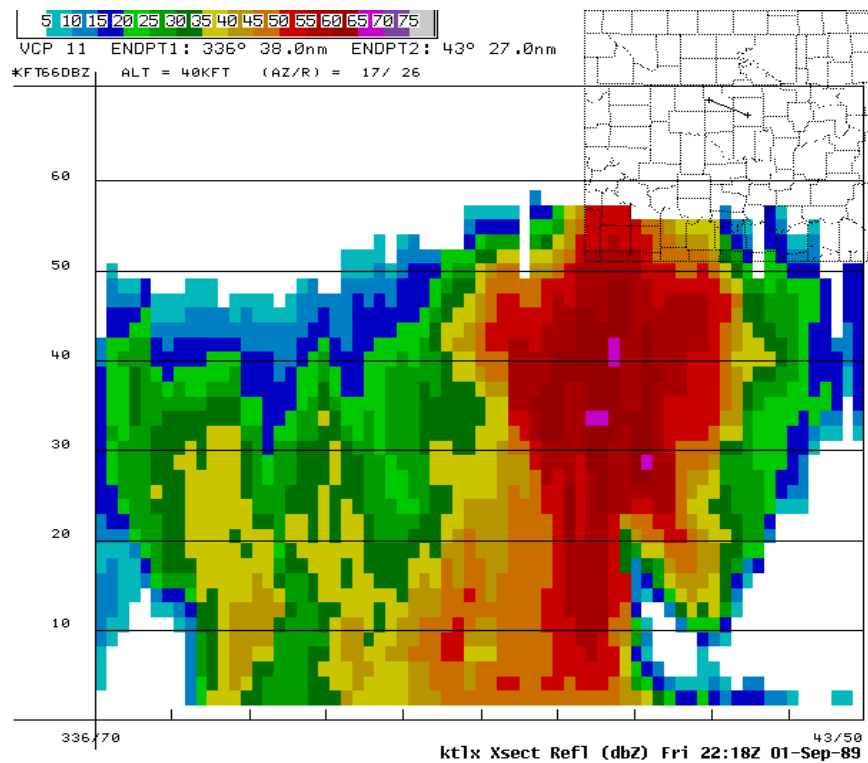


Figure 1. Reflectivity Cross Section.

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9. Using the four-panel reflectivity product, this storm is exhibiting:
- Convergence
 - A weak echo region.
 - A bounded weak echo region.

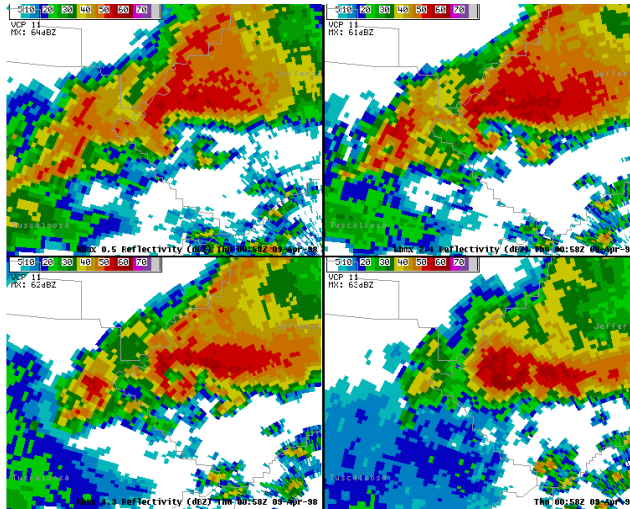


Figure 2. Four panel reflectivity centered 30 miles northwest of the RDA.

10. The narrow “spike” depicted between 30kft and 40kft on the left storm in the cross section is:
- A result of interpolation in the current scan strategy.
 - A Three-Body Scatter Spike, indicative of large hail.
 - Related to algorithm failure.

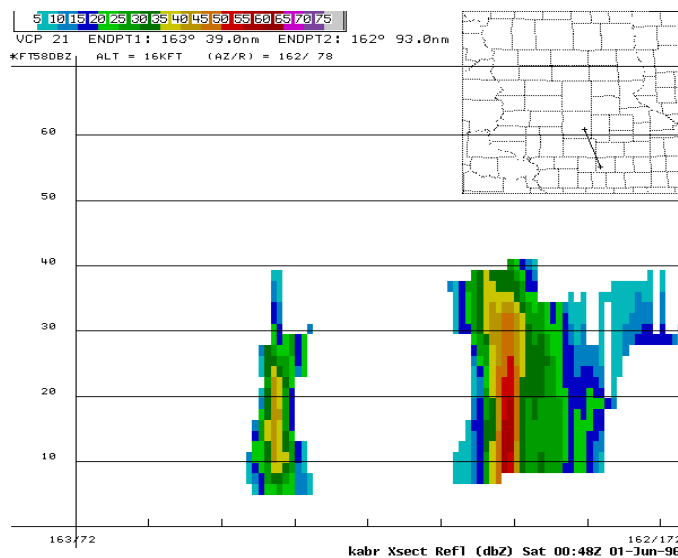


Figure 3. Reflectivity Cross Section.

11. It's summertime in the Rockies. Thunderstorms have developed in the monsoon moisture streaming northward. On the day in question, a severe thunderstorm watch

is in effect. The VIL threshold established on this day is approximately 45. After looking at the information provided, what kind of action would you take for the storm centered in each of the products?

- Issue a severe thunderstorm warning.
- Issue a tornado warning.
- Wait for another volume scan to make a decision.
- Wait for spotter confirmation to make a decision.

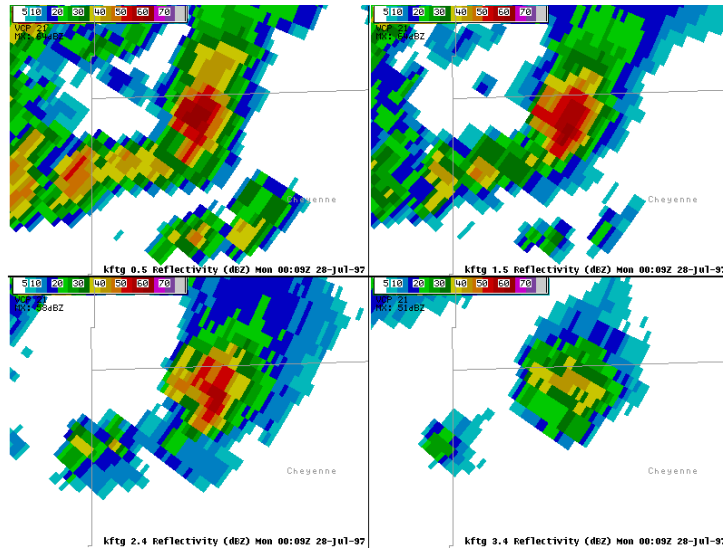


Figure 4. Four panel reflectivity product. The range to the storm is around 90nm. The altitude of 2.4 degree slice is around 28Kft. The altitude for the 3.4 degree slice is near 37Kft.

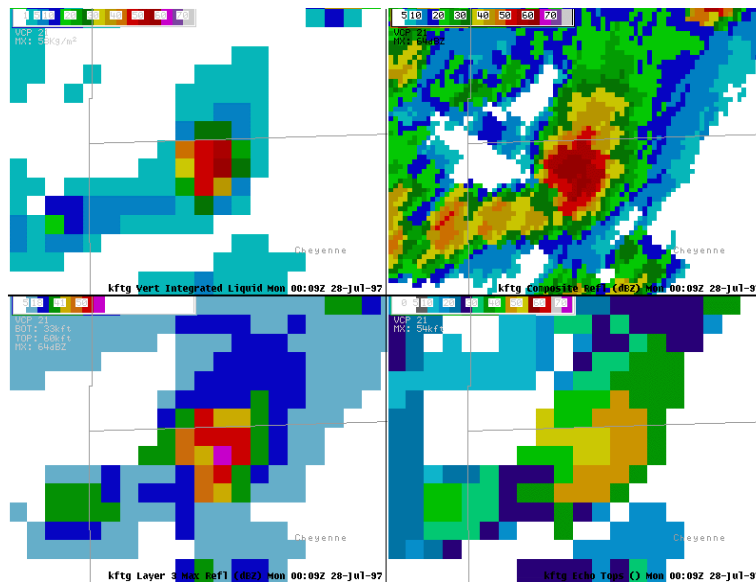


Figure 5. VIL(max 55), CR(max 60dBZ), LRM-M(max 57dBZ) and ET(max 50Kft) product for the same storm at the same time.

Review Exercises Reflectivity Derived Products *****ANSWERS*****

Be sure to check each answer if you are not sure why they are wrong or right.

1. True or False Cell-Based VIL will *usually* be more accurate than Grid VIL for a fast moving storm.
The answer is TRUE. Remember that Cell-Based VIL will attempt to identify the cell even when the upper components are not vertically stacked. Grid VIL will likely underestimate the storm as the upper components will fall in grid boxes adjacent to those for the lower components. This is due to the continued motion of the storm during the time it takes to complete the volume scan.

2. Which of the following statements about the Composite Reflectivity product is true?
 - a) The height of the maximum reflectivity for each resolution grid box is known.
No way! This is one of the limitations of the CR product. You do NOT know from what elevation angle each reflectivity value comes.

 - b) The product is useful for locating hook echoes, when present with a storm.
Egad! This is NOT where you want to look for hook echoes or pendants. It would be a misapplication of this product (kinda like using a toaster to make Jell-O - nothing wrong with the toaster...except if you're using it to make Jell-O!) In a CR product, the echo overhang often masks the hook echo. You would therefore refer back to a Base Reflectivity product for this feature.

 - c) Echo aloft can not be discriminated from precipitation reaching the surface.
Very true! This is why you don't want to use this product to brief anyone on where it may or may not be raining. Echo aloft (such as cirrus anvil) may look exactly like light rain. Comparing the CR to a Base Reflectivity product will help make this discrimination.

3. The Echo Tops product will be useful for distinguishing:
 - a) between liquid and frozen precipitation.
Sorry. It will give an estimate of the top of the echo, but will tell you nothing about precipitation type or intensity.

 - b) the height of higher dBZ's.
Incorrect. Think about this for a second. You know that at the height indicated on this product, there is echo of 18.3dBZ or greater. But that is all you know. You don't know anything about the height of the 30dBz core or the 50dBZ core, for example. You would want to use a cross section or a 4panel Reflectivity product or the *All Tilts* feature on AWIPS for that.

 - c) AP from precipitation echoes.
Yes. Since AP doesn't usually have much vertical extent, this is a good

application of this product.

4. True or False The base altitude for the LRM Low Layer product must be no less than 6 thousand feet MSL.
False. The *depth* of the lowest layer must be no less than 6 thousand feet. The base altitude can be set at whatever the site prefers (as long as it is above the altitude of the radar itself).
5. When examining a thunderstorm, one strength of the Reflectivity Cross Section product is:
a) to estimate storm top divergence.
Negative. You need velocity to estimate divergence. This will be an application of the Velocity Cross Section to be discussed later.
b) the combined attribute table is available.
No. Sometimes people will confuse the names of the Reflectivity Cross Section and the Composite Reflectivity (which *does* have an attribute table with it). If you picture the RCS, you will likely remember that this is *not* where you find the Combined Attribute Table.
c) to evaluate the height of higher dBZ's.
Yes! You must be careful with the placement of the cross section line through the storm, but you can use the resulting RCS to evaluate the height of the 50 dBZ core, for example.
6. The Layer Composite Reflectivity Maximum *mid-level* product will often be useful in determining:
a) The location of BWERs when present.
No! Any BWER which is present in mid levels will likely be masked by higher reflectivity echo above the BWER in that layer. Just as the CR product is not the place to look for signatures such as pendants and hook echoes, the LRM, which basically uses the same process, should also not be used for this purpose.
b) echo development aloft.
Yes! A great application of this product is with elevated convection. You can often see the mid-level development on this product before anything shows up at the surface. This could lead to valuable lead-time for pulse thunderstorms in the summertime.
c) the max dBZ in a storm.
Close! You can see the max dBZ in that *layer*, but you would have to check all three layers to determine the max in the storm.
7. Which of the following products may be effective for detecting storms with $\geq 3/4$ inch hail? (More than one answer possible).
a) Hail Index - ***make sure environmental data is representative***
b) Echo Tops - ***effects of scan strategy on underestimation***

- c) Vertically Integrated Liquid - ***“significant” values change with environment***
- d) Reflectivity Cross Section - ***how well you see storm depends on the cut taken***
- e) Layer Composite Reflectivity Maximum - ***mid/high level, depends on environment***
- f) Composite Reflectivity - ***shows max in storm, but you don’t know what height***
- g) Storm Track - ***could infer something from the attribute table readout which shows the max dBZ and its height***

Answer: Each of these can be effective *when used properly* in the decision making process. You will want to keep in mind the strengths and limitations of each (some of which are listed above), in conjunction with sampling limitations, and be sure to use them with other products. Keep in mind that the lack of convincing evidence on any one product could be a result of these limitations, rather than an actual representation of the storm.

8. **True or False** A bounded weak echo region is located on the *west* side of the storm depicted in the cross section.
False! This is sort of a 2-part question: 1) Do you recognize a BWER, and 2) Can you tell what orientation the cross section samples the storm? Both are important. The cross section does show a BWER, however it is on the east side of the storm. Remember that the origin of a cross section is the western-most point, unless the line is along the same longitude - in which case the origin is the northern-most point.

9. Using the four-panel reflectivity product, this storm is exhibiting a:
 - a) Convergence
It may well have convergence but we’d need a velocity product to see this.

 - b) Weak echo region.
Yes but “c” is probably a better answer.

 - c) Bounded weak echo region.
Yes! In a four panel, the BWER will show up as a “donut”. The storm exhibits a hook in quadrant 1 , almost a complete BWER in quadrant 2, and a definite BWER (donut) in the 3rd (lower left) quadrant.

10. The narrow “spike” depicted between 30kft and 40kft on the left storm in the cross section is:

a) A result of interpolation in the current scan strategy.

Yes. The cross section process interpolates from one elevation cut to the next higher cut where data are detected. This cross section obviously went through two pixels of reflectivity at the higher slice (looks like it was around 5dBZ). It then had to interpolate between that pixel and whatever was below it on the previous slice. This is indeed an artifact of the interpolation process when used with discrete elevation sampling.

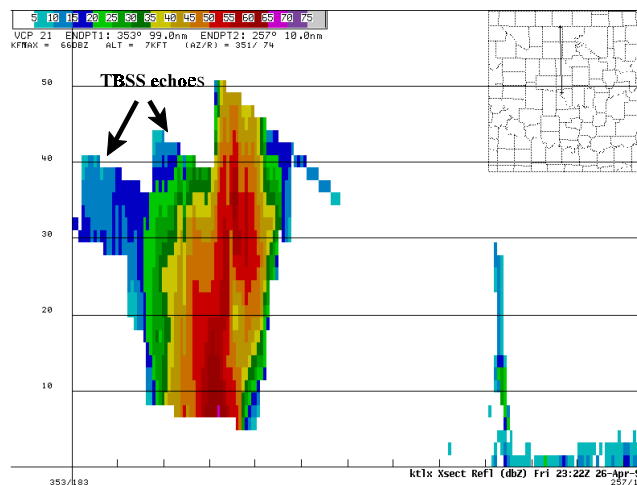
b) A Three-Body Scatter Spike, indicative of large hail

No. This is not a three-body scatter spike. The cross section process interpolates from one elevation cut to the next higher cut. This cross section obviously went through two pixels of reflectivity at the higher slice (looks like it was around 5dBZ). It then had to interpolate between that pixel and whatever was below it on the previous slice. This is indeed an artifact of the interpolation process.

For an example of a TBSS, look at figure the figure below. This on the other hand, is a three-body scatter spike as shown in a cross section. The TBSS is the weak reflectivities which extend *down-radial* from the high reflectivity core.

c) Related to algorithm failure

No - the algorithm did what it was suppose to do and that is interpolate between elevation cuts. The cross section process interpolates from one elevation cut to the next higher cut. This cross section obviously went through two pixels of reflectivity at the higher slice. It then had to interpolate between that pixel and whatever was below it on the previous slice. This is indeed an artifact of the interpolation process.



11. It's summertime in the Rockies. Thunderstorms have developed in the monsoon moisture streaming northward. On the day in question, a severe thunderstorm watch is in effect. The VIL threshold established on this day is approximately 45. After looking at the information provided, what kind of action would you take for the storm centered in each of the products?
- a) Issue a severe thunderstorm warning.
 - b) Issue a tornado warning.
 - c) Wait for another volume scan to make a decision.
 - d) Wait for spotter confirmation to make a decision.

Considerations: The four panel shows 50-55dBZ extending up at least to 28kft or higher. The LRM-M indicates at least 57 dBZ somewhere in the layer between 24-36kft. The VIL is above your threshold of 45 (for 3/4 inch hail) but it is at a fairly long range and may be slightly overestimated. The CR product is detecting 60dBZ although it doesn't show up in any of the 4 slices in the 4-panel.

Warning Decision:

Issue a SVR: If you were to issue an SVR, it should be now (or maybe a while ago). Otherwise, you will have no lead time. The vertical extent of the high reflectivity core is significant enough that you would expect fairly large hail (considering the time of year and the environment). This is supported by the VIL values as well as the size of the core as represented by the VIL product. All the other product input supports this as well. Sampling limitations seem to be having a minimal impact on the storms presentation.

Issue a TOR: This is a possibility. However, as far as a tornado warning goes, what *information provided here* would support this decision? Probably very little.

Wait for another volume scan: You could also do this. If you choose to wait, you should have in mind what it is you're waiting to see which will cause you to warn. Frankly, we've seen enough.

Wait for spotter input: You could also do this. Something to keep in mind is what kind of input would you want to hear that would cause you to issue a warning (and still have positive lead time.) Also remember there are times and places where spotter reports are few and far between...don't wait on them if other inputs are convincing.

What happened: There is no right or wrong answer. There are however, good decisions which will stand up to any scrutiny, regardless of the outcome, and bad decisions which may be based on erroneous information or logic. A good decision here is one based on the proper use of all the information provided, including the strengths and limitations of the products as well as the radar. This storm had a history of producing golfball hail and would produce nickel size hail shortly.

8/02

Worksheet Velocity Derived Products

The following pertain to the Velocity Derived Products. Answer them if you desire a little extra practice. The answers are included at the end of the worksheet.

1. What is the default storm motion for the Storm-Relative Mean Radial Velocity Map (SRM) product?

2. What is the default storm motion for the Storm-Relative Mean Radial Velocity Region (SRR) product?

3. For each of the phenomena listed below, select which product would be most effective, Storm Relative Map(SRM) using the default storm motion, Severe Weather Analysis Velocity (SWV), Storm Relative Region (SRR), or a Base Velocity (V).
 - a) Mesocyclones in a series of fast moving storms. _____
 - b) Winds associated with a cold front 20 miles from the RDA. _____
 - c) Circulation in a storm with a deviant motion. _____
 - d) Winds associated with a bow echo 10 miles from the RDA. _____
 - e) A hurricane. _____
 - f) Residual outflow boundaries on a summer day before convection develops _____

4. How many elevation angles of an SRM product are appropriate on an RPS List? Which angles are best?

5. What type of Velocity Cross Section orientation is necessary to examine the depth of a mesocyclone in a storm?

6. What is the difference between a mesocyclone and a 3-D Correlated Shear?

7. What will be the impact of lowering the threshold pattern vectors (TPV) in the mesocyclone algorithm from 10 to 6? In what situation would you want to make this change?
8. In what official document can you find the values for the parameter sets used in the TDA algorithm?
9. Why might you find a TVS labeled with “??” instead of an ID? How would that TVS be listed on the Combined Attribute Table?
10. Which product would you examine to check wind data that appears "suspicious" on the VAD Wind Profile?
11. State two reasons why it is more desirable to examine a storm scale shear region with the SRR product instead of the SRM product?
12. Why is the SRM product usually placed on the RPS list, while the SRR product is not?
13. Why would you find the max inbound and outbound winds more useful on the SRR product than the SRM product?

**Worksheet
Velocity Derived Products**

*******ANSWERS*******

1. What is the default storm motion for the Storm-Relative Mean Radial Velocity Map (SRM) product?
The average motion of all identified storms. The average will be from the previous volume scan.
2. What is the default storm motion for the Storm-Relative Mean Radial Velocity Region (SRR) product?
The motion of the storm closest to the product center. This also will be from the previous volume scan.
3. For each of the phenomena listed below, select which product would be most effective, Storm Relative Map(SRM) using the default storm motion, Severe Weather Analysis Velocity (SWV), Storm Relative Region (SRR), or a Base Velocity (V).
 - a) Mesocyclones in a series of fast moving storms.
SRM - It is the quickest way to get an overall look at storm relative motions, especially when there are a lot of storms to look at.
 - b) Winds associated with a cold front 20 miles from the RDA.
Base Velocity - .13nm. This will show ground relative winds. The .13nm resolution extends out to 32nm.
 - c) Circulation in a storm with a deviant motion.
SRR - We want storm relative velocity because we are looking for a circulation. We want the SRR instead of the SRM because the storm of interest has a motion deviant from the average of all. The SRR will use the motion of the deviant storm (assuming that's what you center the window on).
 - d) Winds associated with a bow echo 10 miles from the RDA.
Base Velocity - .13nm. Once again we want ground relative winds. The .13nm Base Velocity product extends out to 32nm.
 - e) A hurricane.
Base Velocity. You will probably want several slices of a Base Velocity product on the RPS list to look at a hurricane. The resolution you use will depend on the range to the hurricane.
 - f) Residual outflow boundaries on a summer day before convection develops.
SRM. The SRM is good for this situation for a couple of reasons. First if convection hasn't developed yet, then no storms will be identified and therefore, no storm motion will be subtracted from the velocity product.

This would make the SRM essentially a base velocity (ground relative) product. If this is so, then why the SRM and not a Base Velocity? Recall that the SRM uses the MAX of each of the four .13nm velocity bins when determining the value for the .54nm product. The Base Velocity product on the other hand, uses the 1st of the 4 bins. When you have light winds and residual boundaries around, this difference can make the boundaries much easier to see in the velocity data.

4. How many elevation angles of an SRM product are appropriate on an RPS List. Which angles are best?

At least 4 elevation angles (to place in a 4panel SRM). The angles you choose will depend on your VCP and the range to the storms (low and high angles for storms close in, low angles for storms far out). For proper storm interrogation, you will also want to choose angles which will sample storms and low, mid, and high levels. With a 56kb line, you can add additional slices which would make it easier to select a variety of 4panels as well as take advantage of the ALL TILTS feature.

5. What type of Velocity Cross Section orientation is necessary to examine the depth of a mesocyclone in a storm?

**To see circulation, you will want a VCS perpendicular to the beam. Try to center the line at the center of the mesocyclone.
(To evaluate low level convergence, updraft/downdraft interface, and upper level divergence, you need a VCS along a radial.)**

6. What is the difference between a mesocyclone and a 3-D Correlated Shear?
In the MESO algorithm, the only difference between these two is the mesocyclone meets symmetry criteria, and the 3DC does not.

7. What will be the impact of lowering the threshold pattern vectors (TPV) in the mesocyclone algorithm from 10 to 6? In what situation would you want to make this change?

Lowering the requirement for the number of pattern vectors in an identified feature will allow smaller features to be detected. You might want to do this in situations where small scale, low topped, or shallow features are expected.

8. In what official document can you find the values for the parameter sets used in the TDA algorithm?

The RPG Adaptable Parameters Handbook (*section 6.15 Tornado Detection Algorithm.*)

9. Why might you find a TVS labeled with “??” instead of an ID? How will that TVS be listed on the Combined Attribute Table?

A TVS or ETVS will be labeled with “??” if there was no SCIT identified storm within 20km of the feature. Features labeled this way will NOT be listed on the Combined Attribute table since this table starts with *identified* storms and then lists only their attributes. Any features not associated with a SCIT identified storm are not listed. They will, however, be listed on the

TVS Attribute Table.

10. Which product would you examine to check wind data that appears "suspicious" on the VAD Wind Profile?
If winds look funky on the VWP, you can do a one-time-request for a VAD wind at the offending altitude. You can then see the actual sample points and their relationship to the plotted sine wave.
11. State two reasons why it is more desirable to examine a storm scale shear region with the SRR product instead of the SRM product?
The SRR has better resolution and should use a better storm motion than the SRM.
12. Why is the SRM product usually placed on the RPS list, while the SRR product is not?
Even though the SRR should give better results, it is not likely to be put on the RPS List since it has a limited viewing range and requires an AZRAN centerpoint (which you don't know ahead of time). Most often, operators will put several SRMs on the RPS list and get a good quick look at potential circulations. Then if time permits, they may choose to do a one-time request the SRR on a storm in particular.
13. Why would you find the max inbound and outbound winds more useful on the SRR product than the SRM product?
The max inbound/outbound velocities are more useful on the SRR because they only apply to the small window product. It is difficult to use these values on the SRM because they may refer to anywhere on the product, not just a storm of interest.

8/02

REVIEW EXERCISES

Velocity Derived Products

Instructions: Select the most correct answer. Questions 11 and 12 use the supplied figures. Answers are attached. No peeking allowed.

1. When the ground-relative winds are important, what should be used?
 - a) High resolution Base Velocity
 - b) Storm Relative Region with the default storm motion
 - c) Storm Relative Map product with the default storm motion

2. If a Velocity Cross Section is generated along a radial, the operator can evaluate the _____.
 - a) strength of a circulation
 - b) depth of a mesocyclone
 - c) the strength of the storm top divergence

3. **True or False** The VAD algorithm needs at least 180 degrees of data before it will fit a sine wave to the data points.

4. Which product is generated in a small geographical area and the displayed max inbound and max outbound velocities are often more useful?
 - a) Base Velocity product
 - b) Storm-Relative Mean Radial Velocity Map
 - c) Storm-Relative Mean Radial Velocity Region

5. Which of the following statements concerning the Mesocyclone product is true?
 - a) A 3-D Correlated Shear is a precursor to a mesocyclone.
 - b) The algorithm mesocyclone must contain circulations that are at least 10,000 ft deep.
 - c) Time continuity is not employed.

6. **True or False** The TDA algorithm only searches identified mesocyclones for the occurrence of a TVS or ETVS.

7. Which of these is true about the TDA algorithm and TVS product?
- a) The operator at the ORPG HCI can choose to limit the number of ETVSs which are transmitted for display.
 - b) Individual values within the adaptable parameter sets can be changed independently.
 - c) Identified TVSs will always have their bases on the lowest elevation angle.
8. One strength of the VAD Wind Profile is to display the:
- a) strength of a low level jet.
 - b) symmetry error.
 - c) sine wave curve.
9. Which of these products are you likely to have on your RPS List to help you evaluate the strength and depth of mesocyclones?
- a) VAD
 - b) Velocity Cross Section
 - c) Storm-Relative Mean Radial Velocity Region
 - d) Storm-Relative Mean Radial Velocity Map

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Question 10 uses the figure provided.

10. Using figure 1, the winds appear reasonably accurate in the 10,000 - 15,000 ft range since ____.

- a) the symmetry is near zero
- b) the RMS error is low
- c) there are only a few "ND" points

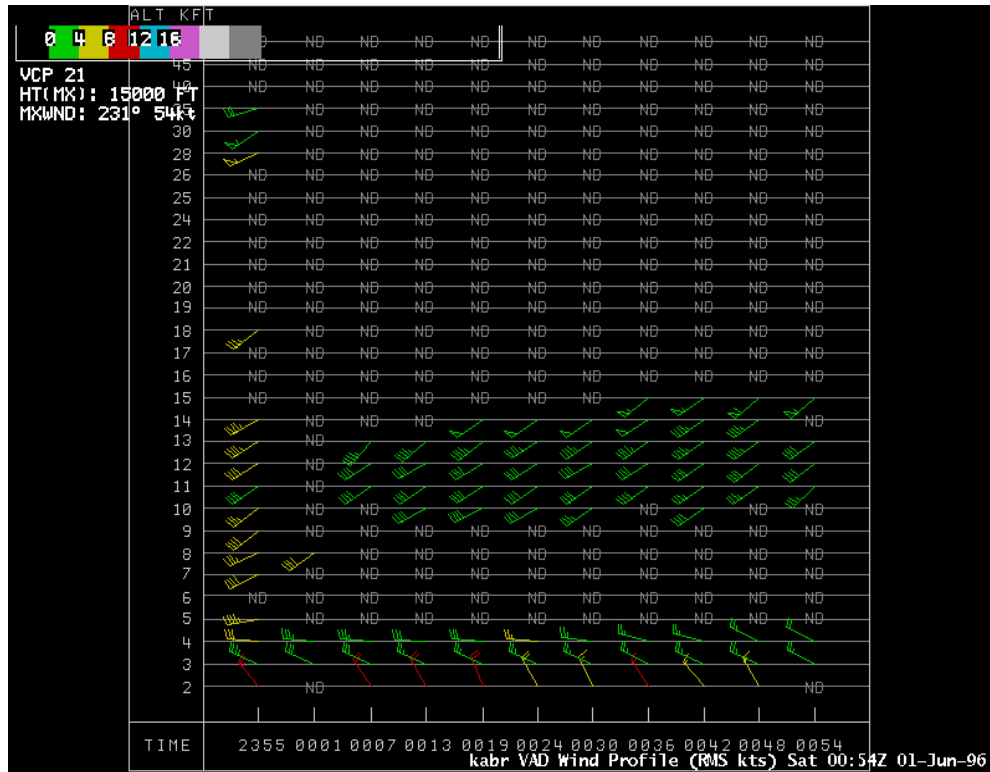


Figure 1. VAD Wind Profile.

REVIEW EXERCISES

Velocity Derived Products

*****ANSWERS*****

Be sure and check each answer if you're not sure why each is wrong or right.

1. When the ground-relative winds are important, what should be used?
 - a) High resolution Base Velocity
Absolutely! If looking for the strength of gradient winds or the strength of a gust front, you want *ground relative* winds (no storm motion subtracted out). All the Base Velocity products are ground relative by definition. The higher the resolution you can use, the more complete the information will be.
 - b) Storm Relative Region with the default storm motion
No. It would be a mis-application of the SRR or the SRM to use either one to detect ground relative winds. Their strength is in subtracting out storm motion to see rotational signatures, not in assessing ground relative winds.
 - c) Storm Relative Map product with the default storm motion
No. It would be a mis-application of the SRR or the SRM to use either one to detect ground relative winds. Their strength is in subtracting out storm motion to see rotational signatures, not in assessing ground relative winds.
2. If a Velocity Cross Section is generated along a radial, the operator can evaluate the _____.
 - a) _____ strength of a circulation
False. While you can use a VCS to estimate this, the cross section needs to be *perpendicular to the radial* and centered on the feature. One way to remember this is that in order to see rotation, you must see more than one azimuth, which shows inbound velocities adjacent to outbound velocities (at approximately the same range.) You do not have adjacent azimuths if the VCS is taken along a radial.
 - b) _____ depth of a mesocyclone
False. While you can use a VCS to estimate this, the cross section needs to be *perpendicular to the radial* and centered on the feature. One way to remember this is that in order to see rotation, you must see more than one azimuth, which shows inbound velocities adjacent to outbound velocities (at approximately the same range.) You do not have adjacent azimuths if the VCS is taken along a radial.
 - c) _____ the strength of the storm top divergence
Yes. A VCS taken down radial, especially through the inflow side of the

storm, can allow you to infer convergence at low levels, the updraft/downdraft interface, and storm top divergence.

3. **True or False** The VAD algorithm needs at least 180 degrees of data before it will fit a sine wave to the data points.
The answer is False! The VAD algorithm need 25 data points (from 25 degrees of data) in order to make an attempt to fit a sine wave to the points. This means it can still get pretty good estimates even when there is not widespread echo. This is a strength of the algorithm.

4. Which product is generated in a small geographical area and the displayed max inbound and max outbound velocities are often more useful.
 - a) Base Velocity product
Probably not. More often than not, the max values listed on the Base Velocity product will be from some spurious return near the RDA site.
 - b) Storm-Relative Mean Radial Velocity Map
Probably not. More often than not, the max values listed on the SRM product will be from some spurious return near the RDA site.
 - c) Storm-Relative Mean Radial Velocity Region
This is the one! Since the max inbound and max outbound velocities only apply to the area covered by the SRR, they can be very useful if any of the data points of interest are “thresholded” at 50kts. Chances are the max values listed, will be contained in these “maxed out” velocities.

5. Which of the following statements concerning the Mesocyclone product is true?
 - a) A 3-D Correlated Shear is a precursor to a mesocyclone.
Don't be fooled! Whether or not a feature gets classified as a 3-D Correlated Shear (3DC) or a MESO is a measure of “symmetry”, i.e. how close the azimuthal diameter is to the diameter along the radial. This could be entirely a function of sampling! Features may go back and forth between these two classifications merely because of sampling, not because of anything meteorological.
 - b) The Meso algorithm requires circulations to be at least 10,000 ft deep.
The algorithm's “depth requirement” is *at least 2 elevation cuts*. This could be substantially less than 10Kft if the feature is very close to the radar. This is why very shallow features, along a gust front nearing the radar for example, may be classified as MESOs. The *operator* identification of a mesocyclone uses the 10Kft depth as an approximation for height continuity. (The operator of course may choose to lower this value depending on the overall depth of the storm).
 - c) Time continuity is not employed.
Yes! The algorithm does not employ time continuity. Transient shears which pass all other tests may be identified one volume scan and lost the

next. Once again it is the operator who must employ time continuity to help weed out transient shears.

6. **True or False** The TDA algorithm only searches identified mesocyclones for the presence of a TVS or ETVS.

False! The TDA algorithm returns to the base velocity data to do its processing and runs independently of the mesocyclone algorithm.

7. Which of these is true about the TDA algorithm and TVS product?

- a) The operator at the ORPG HCI can choose to limit the number of ETVSs which are transmitted for display.

Yes! The UCP/ORPG HCI operator can set the number of ETVSs from 0 to 25. Specifying a number other than zero will cause the algorithm to limit the product to the specified number of ETVSs, starting with the strongest ETVSs (based on the Min 3D Feature Low Level Delta -LLDV).

- b) Individual values within the adaptable parameter sets can be changed independently.

No. At this time, the adaptable parameter sets must be changed as a unit. You cannot change one value in the set without changing all the values in the set. However, experimentation can be done on individual parameter changes with an *offline* system such as WATADS.

- c) Identified TVSs will always have their bases on the lowest elevation angle.
Not necessarily. Features very close to the radar may have their bases on elevations higher than 0.5 degrees. The TVS definition requires the base to be at 0.5 degrees, but they can also be on higher slices as long as they remain below 600 meters.

8. One strength of the VAD Wind Profile is to display the:

- a) strength of a low level jet.

Absolutely! This is something you can evaluate time and height wise using the VWP.

- b) symmetry error.

You are probably confusing the VAD with the VWP. The VAD is where you find the sine curve, from which the algorithm calculates symmetry (the first term in the least squares equation on the bottom of the product). In contrast, the VAD Wind Profile shows the wind barbs plotted with time and height (much like the profilers).

- c) sine wave curve.

You are probably confusing the VAD with the VWP. The VAD is where you find the sine curve The VAD Wind Profile shows the wind barbs plotted with time and height (much like the profilers).

9. Which of these products are you likely to have on your RPS List to help you evaluate the strength and depth of mesocyclones?

a) VAD

Not even close! You may well put this on your RPS List, but it will not help you with evaluating mesocyclones. Recall that the VAD works best in homogeneous wind flow situations and was not designed to diagnose small scale rotations. It can also help you diagnose suspicious winds on the VWP. However, it will tell you nothing about a small scale feature such as a Meso.

b) Velocity Cross Section

Sort of close. You can use a VCS to evaluate the depth and strength of a mesocyclone, however, you will likely NOT have this on your RPS list since you don't know where the circulation will be ahead of time.

c) Storm-Relative Mean Radial Velocity Region

You're half right. You can use SRR to evaluate depth and strength of a mesocyclone, however, you will likely NOT put SRRs on your RPS list since you don't know where the circulation will be ahead of time.

d) Storm-Relative Mean Radial Velocity Map

This is the one! No doubt, most convective RPS Lists at most dedicated user sites in the country have several slices of SRM on them to help evaluate the strength and depth of mesocyclones. Most sites will also have matching procedures to quickly display 4 elevations of the SRM to help in the evaluation.

Questions 10 uses the figure provided.

10. The winds appear reasonably accurate in the 10,000 - 15,000 ft range since ____.

a) the symmetry is near zero

Not really. While the symmetry may indeed be near zero, there is no way to tell that from this product. You'd have to go to a VAD in order to see that.

b) the RMS error is low

Yes! The RMS error is a measure of how well the sine curve fits the sample points. The lower it is, the better the fit. The better the fit, the more representative the wind calculated from that sine curve will be. The RMS error for these winds (which we can see via the color coding) is very low.

c) there are only a few "ND" points

Sorry. Data sampled for one altitude really has nothing to do with those sampled at another altitude. You may very well have almost all altitudes showing ND, with only one or two winds being plotted. If the RMS error is low for these winds (note color table), then you can infer they are reasonable. You may simply have had no scatterers at the altitudes where you have ND.

Precipitation Products and Algorithms Review Exercise

Match the Product on the right to the Product Characteristic on the left. (Some characteristics will describe more than one product, thus more than one letter may be used).

- | | |
|--|--|
| 1. _____ Resolution 1.1nm x 1 degree | A. Digital Hybrid Reflectivity (DHR) |
| 2. _____ Resolution 0.54nm x 1 degree | B. Hybrid Scan Reflectivity (HSR) |
| 3. _____ Updated each volume scan | C. One Hour Precipitation (OHP) |
| 4. _____ Updated at the top of the hour | D. Three Hour Precipitation (THP) |
| 5. _____ 16 Data levels | E. Storm Total Precipitation (STP) |
| 6. _____ 256 Data levels | F. User Selectable Precipitation (USP) |
| 7. _____ Available as an alphanumeric product only | G. Digital Precipitation Array (DPA) |
| 8. _____ Not displayable at WFO AWIPS workstation | H. Supplemental Precipitation Data (SPD) |
| 9. _____ corresponds to the Flash Flood Guidance time interval | |
| 10. _____ can be generated for a specified period of time | |

Identify true statements below with a T and false statements with an F.

10. _____ The digital Three Hour Product is used directly by RFC computers as input to the hydrologic models (NWSRFS).
11. _____ The Precipitation Processing Subsystem can eliminate any hail contamination.
12. _____ Missing volume scans do not affect the accuracy of the radar precipitation estimates.
13. _____ A multiplicative bias is calculated in AWIPS using rain gauge to radar comparisons, and sent to the RPG.
14. _____ The Precipitation Processing Subsystem algorithms contain significant quality control steps.
15. _____ Adjusting the Nominal Clutter Area suppresses Anomalous Propagation and thus reduces the contamination of precipitation estimates.

For all questions on this page, assume that the rainfall event occurred in a 6 hour period, and that the flash flood guidance given is for 6 hours. Each of the 3 figures should be treated as separate events.

For questions 16 and 17, use Fig. 1.

16. In _____ county, the radar data is _____ due to _____.

- A. Y...unreliable...evidence of double bright band contamination.
- B. X...unreliable...evidence of overestimation.
- C. Z...reliable...good rain gage correlation.
- D. Y...unreliable...evidence of underestimation.

17. Rain occurred shortly after Flash Flood Guidance issuance time. The rain event that you see in Figure 1 occurred much later in the day, after a period of clear air (category 0). Thus the Flash Flood Guidance was invalid for the duration of this event. Which of the above counties would be the HIGHEST priority for further investigation?

For question 18, use Fig. 2 and 6 hour Flash Flood Guidance 4.9 inches for all counties.

18. Using the STP as a "first look", _____ county would be the HIGHEST priority for further investigation of flash flooding.

For questions 19 and 20, use Fig. 3 and the following 6 hour Flash Flood Guidance values.

X County 2.0 inches

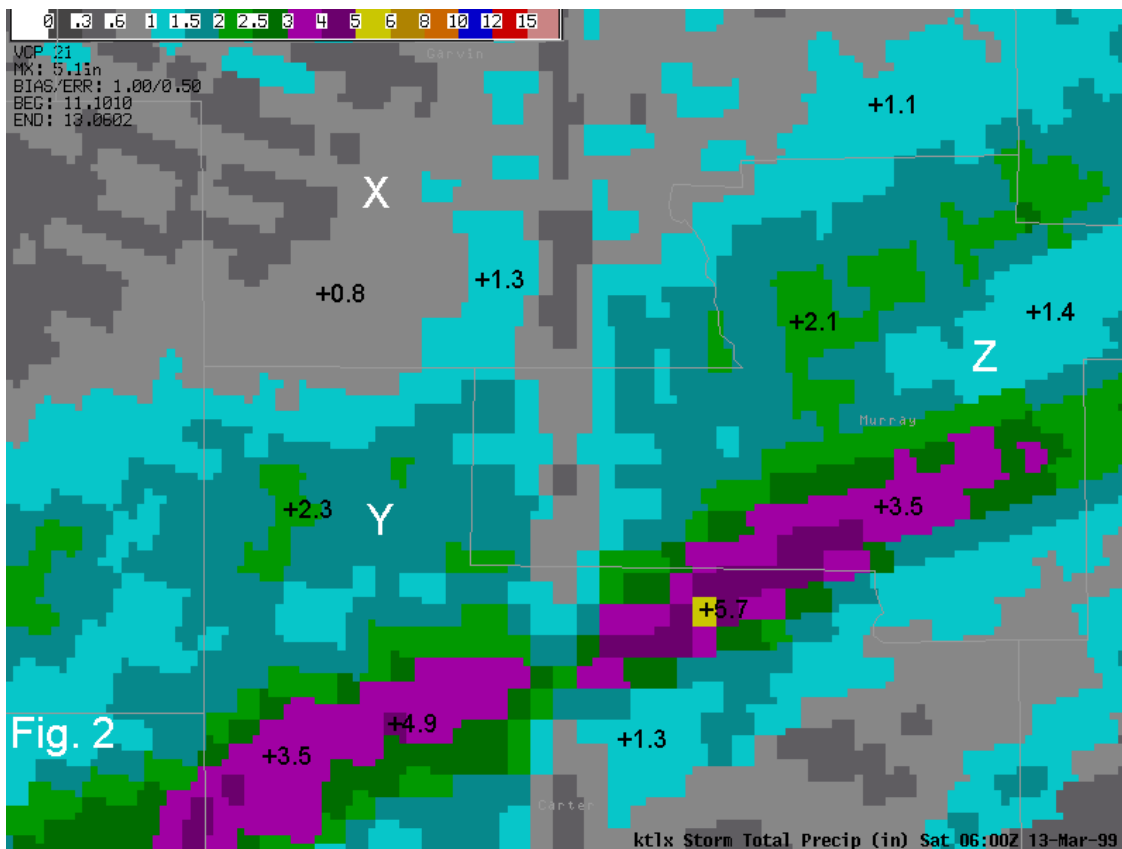
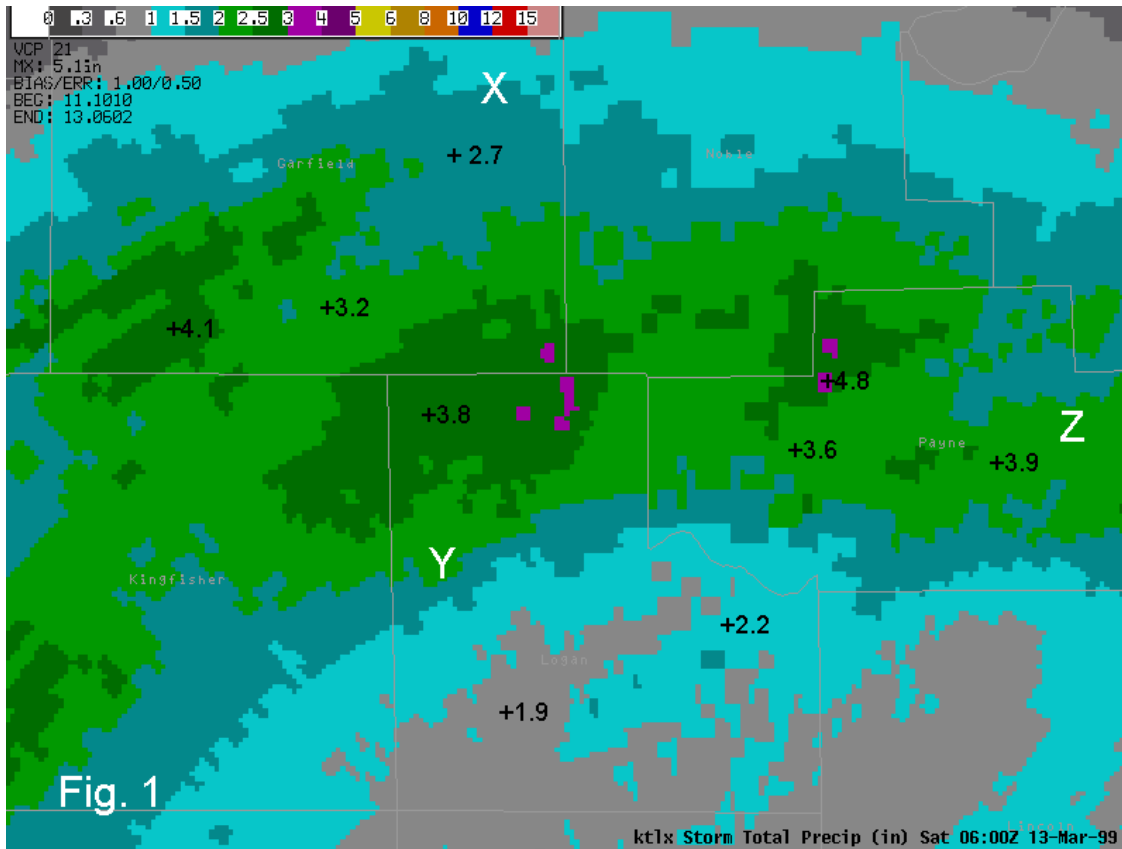
Y County 2.5 inches

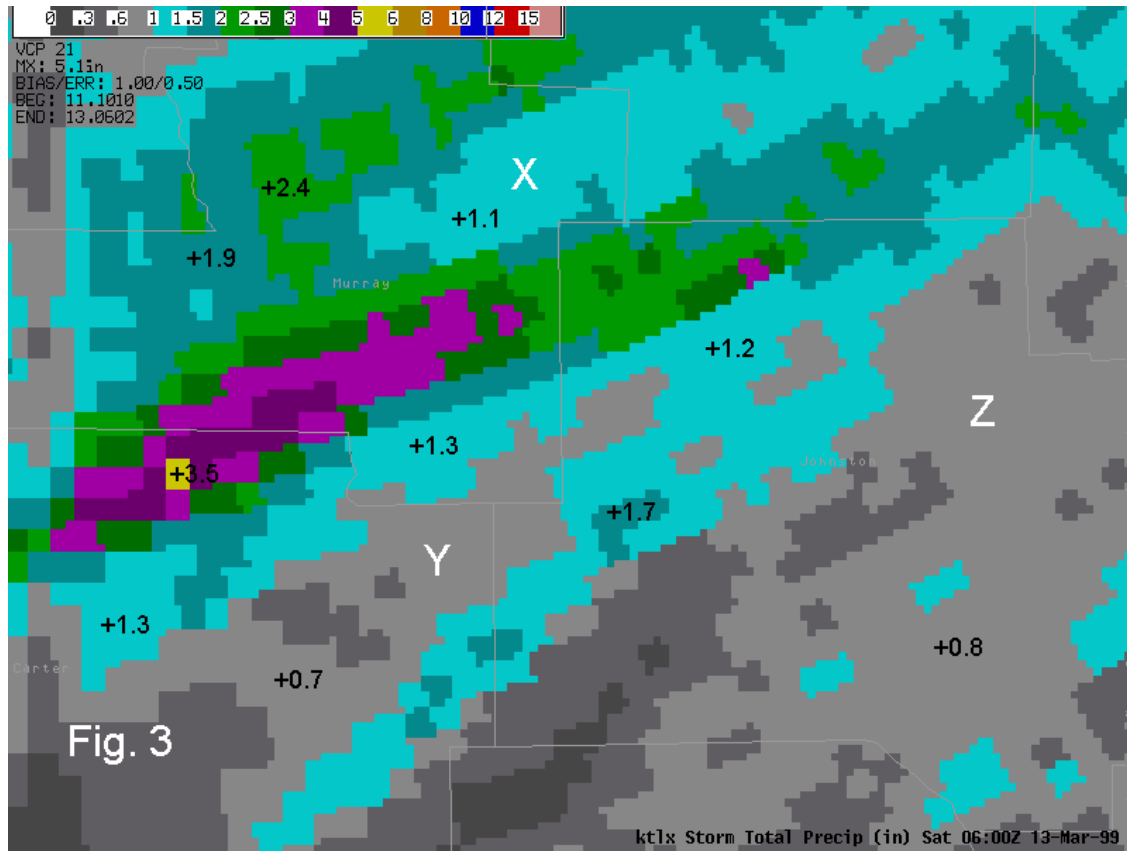
Z County 2.2 inches

19. Using the STP as a "first look", _____ county would be the HIGHEST priority for further investigation of flash flooding.

20. Which counties, if any, would also require further investigation or monitoring?

IC 5.5 WSR-88D Derived Products





Answer Key: Precipitation Products and Algorithms Review Exercise

Match the Product on the right to the Product Characteristic on the left. (Some characteristics will describe more than one product, thus more than one letter may be used).

- | | |
|---|--|
| 1. <u>C,D,E,F</u> Resolution 1.1nm x 1 degree | A. Digital Hybrid Reflectivity (DHR) |
| 2. <u>A,B</u> Resolution 0.54nm x 1 degree | B. Hybrid Scan Reflectivity (HSR) |
| 3. <u>A,B,C,E,G,H</u> Updated each volume scan | C. One Hour Precipitation (OHP) |
| 4. <u>D,F,H</u> Updated at the top of the hour | D. Three Hour Precipitation (THP) |
| 5. <u>B,C,D,E,F</u> 16 Data levels | E. Storm Total Precipitation (STP) |
| 6. <u>A,G</u> 256 Data levels | F. User Selectable Precipitation (USP) |
| 7. <u>H</u> Available as an alphanumeric product only | G. Digital Precipitation Array (DPA) |
| 8. <u>G</u> Not displayable at WFO AWIPS workstation | H. Supplemental Precipitation Data (SPD) |
| 9. <u>D</u> corresponds to the Flash Flood Guidance time interval | |
| 10. <u>F</u> can be generated for a specified period of time | |

Identify true statements below with a T and false statements with an F.

10. F The digital Three Hour Product is used directly by RFC computers as input to the hydrologic models (NWSRFS).
11. F The Precipitation Processing Subsystem can eliminate any hail contamination.
12. F Missing volume scans do not affect the accuracy of the radar precipitation estimates.
13. T A multiplicative bias is calculated in AWIPS using rain gauge to radar comparisons, and sent to the RPG.
14. T The Precipitation Processing Subsystem algorithms contain significant quality control steps.
15. F Adjusting the Nominal Clutter Area suppresses Anomalous Propagation and thus reduces the contamination of precipitation estimates.

For all questions on this page, assume that the rainfall event occurred in a 6 hour period, and that the flash flood guidance given is for 6 hours. Each of the 3 figures should be treated as separate events.

For questions 16 and 17, use Fig. 1.

16. In _____ county, the radar data is _____ due to _____.

(D.) Y...unreliable...evidence of underestimation.

17. Rain occurred shortly after Flash Flood Guidance issuance time. The rain event that you see in Figure 1 occurred much later in the day, after a period of clear air (category 0). Thus the Flash Flood Guidance was invalid for the duration of this event. Which of the above counties would be the HIGHEST priority for further investigation?

Z County

For question 18, use Fig. 2 and 6 hour Flash Flood Guidance 4.9 inches for all counties.

18. Using the STP as a "first look", Y county would be the HIGHEST priority for further investigation of flash flooding.

For questions 19 and 20, use Fig. 3 and the following 6 hour Flash Flood Guidance values.

X County 2.0 inches

Y County 2.5 inches

Z County 2.2 inches

19. Using the STP as a "first look", Y county would be the HIGHEST priority for further investigation of flash flooding.

20. Which counties, if any, would also require further investigation or monitoring?

X County

SUMMARY OF LIMITATIONS/STRENGTHS/APPLICATIONS

(These are from those found in the student guide and are provided here for your convenience.)

I. SCIT Products

Storm Track Information Product (STI)

Limitations

1. Errors may occur in the identification of cells and the calculation of cell attributes when cells are in close proximity.
2. Large errors may occur in the attributes of cells close to the RDA, especially in VCP 21.
Discussion: Recall that there are large gaps between elevation angles at higher slices in VCP 21. Calculations of Cell-based VIL, Cell Base, Cell Top, Height of Maximum Reflectivity, etc. can all be adversely affected by what the radar is **not** sampling in these gaps.
3. Unrepresentative movements are possible due to propagational effects.
Discussion: Due to development or dissipation, the high reflectivity cores change location within an identified cell from one volume scan to the next, resulting in false representation of the movement of the cell.
4. Forecast positions of curving cells are displayed as a straight line.
Discussion: Since position forecasts are always in a straight line, the past tracks of a cell should be taken into account when using the position forecast of a curving cell.

Strengths and Applications

1. The product works best with well-defined widely separated cells.
Discussion: Forecast positions in this case can be used in the timing of storms in warnings and nowcasts. Keep in mind that the forecast position is that of the centroid, and that adjustments should be made if the user is trying to time the leading edge of the echo or the location of a tornadic circulation.
2. A large number of past tracks, and/or four forecast positions signifies a more reliable cell movement.
Discussion: Uneven spacing between past tracks, fewer than four forecast positions, and/or re-identification of cells indicate less reliable forecast positions.
3. The STI product is useful as an overlay on volume products, but not limited to volume products.
Discussion: Because the product and overlay are produced at the end of the volume scan, it makes it more convenient to display on top of other volume products such as VIL and CR.
4. Cell motion is used in Storm Relative Velocity products (SRM, SRR)
Discussion: This is what allows us to quickly view a storm relative velocity product to check for circulations. Note that any errors made in the tracking process will also be passed along to the storm relative products.
5. Cell attributes are critical inputs to the Hail Index product and Cell Trends Display.
Discussion: Proper cell identification will improve the value of both the Hail Index Product and the Cell Trends Display.

Hail Index Product (HI)

Limitations

1. The Hail Detection Algorithm needs as input, accurate and timely measurements of the MSL altitudes for the 0° C and -20° C levels.
Discussion: Failure to update this information will degrade the algorithm's performance. Operators

will also want to note this information on products which they get via dial-out.

2. Values of POH, POSH, and MEHS will fluctuate at close ranges, especially in VCP 21, due to gaps in coverage at higher elevation slices.

Discussion: As a cell 50,000 feet at 80 nm moves toward the radar, the 6 degree elevation slice samples the storm at lower altitudes. Therefore POH, POSH, and MEHS would all lower. As the same cell starts moves to less than 50 nm from the radar the 9.9 degree slice begins to sample the cell at 50,000 feet, and the POH, POSH, MEHS suddenly jump not because the cell has changed, just due to how the cell is being sampled.

3. The values for POH, POSH, and MEHS may fluctuate at longer ranges from the radar due to the limited number of slices through the cell.

Discussion: The altitude is calculated using the center-point of the beam. There can be over 10,000 feet difference in the center-points on adjacent slices at ranges over 90 nm. This can cause estimates to change erratically.

4. For cells beyond 124 nm, hail will be identified as UNKNOWN.

Discussion: UNKNOWN is considered a lower priority than zero in attribute tables. This means a severe cell at greater than 124nm from the radar may be listed after an insignificant storm within 124nm of the radar on the Hail Attribute Table and the Composite Reflectivity Combined Attribute Table.

5. **POSH** and **MEHS** have tended to overestimate the chances and size of hail in weak wind and tropical environments.

Discussion: The accuracy of the hail estimates partially depends upon the accuracy of cell (component) information. **MEHS** is an estimation of the largest hail in the cell, and often times, most of the hail from a cell is smaller. The operator has to keep in mind that the MEHS should only be used as a guide. Storm spotters and other operational means should be integrated into the warning decision.

Strengths and Applications

1. The Hail Detection Algorithm has shown a very high probability of detection in cells that contain severe hail, especially greater than one inch diameter hail.

Discussion: A **POSH** of 50% or greater has shown great skill (CSI) as a warning threshold.

Cell Trends Display

Limitations

1. Errors in cell attributes often occur when cells are in close proximity.

Discussion: Trends of cell attributes may be misleading anytime cells are in close proximity.

2. Gaps between higher angles in VCP 21 can adversely affect the cell attributes tracked on the Cell Trends display.

Discussion: It is even possible that a trend of increasing or decreasing cell intensity may be displayed, when in fact the cell is not changing intensity. The Cell Trend display will be most accurate using VCP 11, which has fewer gaps between elevation slices. This limitation is included in the SCIT algorithm section.

Strengths and Applications

1. A large amount of information on an individual cell is displayed on a single easy-to-interpret display.

Discussion: For isolated cells that are greater than 20 nm from the RDA, Cell Trends provides a reasonably accurate view of cell evolution. Since most other algorithms only operate out to 124nm, Cell Trends can provide additional information on storms beyond this range.

II. Reflectivity Derived Products

Vertically Integrated Liquid (VIL)

Limitations

1. VIL values are biased by drop size.
Discussion: Recall that the VIL equation uses Z (reflectivity), and that $Z = nD^6$ where D is the drop size (from the radar equation).
2. Threshold values are airmass dependant. Therefore values for warnings will change seasonally, may change daily, or even across the warning area.
Discussion: Different airmasses will require different warning thresholds!
3. Values within 20 nm of radar are underestimated.
Discussion: Storms moving into the cone of silence will appear to diminish as less and less of the storm is sampled. They will then appear to strengthen as they move out.
4. Grid VIL values will differ from Cell-Based VIL values.
Discussion: Grid VIL values (which is what the VIL product is displaying) are derived for each 2.2 x 2.2 nm grid box where there is any data at any elevation, regardless of whether or not a "cell" has been identified by the SCIT algorithm. On the other hand, Cell-Based VILs require a storm cell to be identified first. Then using the components included in this cell definition, a single VIL for that storm cell is calculated.
5. VIL values for a strongly tilted or a fast moving storm will be **lower** than if the storm was vertical or moving slower.
Discussion: In this case, the upper portion of the storm may extend into another grid box. It is here that a Cell-Based VIL may be more useful.
6. May be contaminated by non-precipitation echoes.
Discussion: If non-precipitation echoes or AP returns exist, they will end up in the reflectivity data, which in turn will cause these data to be used in the VIL calculation.
7. Less VIL fluctuation with VCP 11 than VCP 21.
Discussion: There are fewer gaps in VCP 11, mainly within 60 nm of the radar. Forecasters should keep this in mind when using any one volume scan to infer a trend, especially in VCP 21.
8. Values at distant ranges (> 110 nm) are occasionally **unreliable**.
Discussion: In the VIL calculation, the reflectivity value at 0.5° is integrated down to the ground. At distant ranges the beam may be cutting through the highly reflective hail cores in the mid levels of a storm, producing an overestimation of VIL. Or, in smaller storms the beam may be overshooting the core entirely, resulting in an underestimation.

Strengths and Applications

1. Locate most significant storms.
Discussion: This is especially helpful with significant amounts of echo on the screen. The VIL can help a forecaster know which storm to investigate first, which is extremely important in a data-rich, time-critical situation (such as in a warning environment).
2. Useful for distinguishing storms with large hail once threshold values have been established.
Discussion: Once a threshold is established (by incorporating ground truth), forecasters can infer that storms in the same environment will likely have the same thresholds. Issues regarding the impacts of sampling should always be considered, however.
3. Persistent high VIL values are often associated with supercells.
Discussion: Supercells with extensive reflectivity cores will exhibit relatively large VILs (considerably larger than the "warning threshold"). Keep in mind that this will not be the case for mini supercells, or LP supercells.
4. Rapid decrease in VIL values may signify onset of wind damage.
Discussion: This is similar to the collapse of the storm top and the correlation of this with wind damage. However, you should use caution with this technique. Sampling considerations, especially in VCP 21 close to the radar, or the impact of the cone of silence in any VCP, may cause an apparent, but not actual, drop in VIL.

Reflectivity Cross Section (RCS)

Limitations

1. Cross section placement may hamper evaluation of storm structure.
Discussion: Depending on the cross section placement, different aspects of the storm can be evaluated.
2. Echo tops and bases are truncated with no vertical extrapolation on the highest or lowest elevation angles.
Discussion: This will be more of a problem in VCP 21 close to the radar since there are more gaps to be interpolated across. In addition, echo tops which actually terminate between beam center points on successive elevation angles will be underestimated. Bases on storms at distant ranges will be overestimated due to the effects of earth's curvature on sampling.
3. Height vs. range exaggeration.
Discussion: This has always been the case, with even the RHI presentation. This is because the vertical extent of the product is 70,000 ft, while the maximum range is 124 nm.
4. Small features may be enlarged or missed due to interpolation.
Discussion: Depending on where the elevation slices cut the storm, you could over exaggerate a reflectivity core, or totally miss a BWER. Once again, this will present more of a problem in VCP 21 within around 60 nm of the RDA due to more gaps.
5. Presentation of product dependent upon VCP.
Discussion: Generally the product will be more coarse and blocky looking with VCP 21 than VCP 11. Once again, this is due to more gaps within 60 nm of the radar in VCP 21.
6. Fast moving storms may appear to be strongly tilted.
Discussion: What appears to be an echo overhang in this cross section may actually be an artifact of VCP sampling on a fast moving storm. This is due to the time needed to complete a volume scan and the fact that the storm doesn't hold still during that time. Once again, a little more impact with VCP 21 which takes a minute longer.

Strengths and Applications

1. Detect the vertical extent of clouds/insects/smoke plumes.
Discussion: Regardless of the phenomenon being sampled, the depth or vertical extent can be estimated with a cross section.
2. Verify existence of a bright band.
Discussion: The bright band, a representation of the freezing/melting layer, is depicted on a Base Reflectivity product as a ring of higher reflectivities. On a cross section, it will appear as a band of higher reflectivities.
3. Estimate height of higher dBZ's.
Discussion: Placement is critical when attempting to estimate dBZ heights. Using the VIL, Composite Reflectivity, or a 4panel Reflectivity display may help with placement of the cross section through the reflectivity core of the storm.
4. Evaluate storm structure features.
Discussion: Again, placement is critical in order to see features such as BWER's, WER's, and storm tilt. It may be useful to use a 4-panel reflectivity presentation with linked cursors to find a best fit line that bisects the BWER at several elevations.
5. Estimate echo tops.
Discussion: While this product will display reflectivities down to 5 dBZ in precipitation mode, echo tops can generally be correlated with the height of the 20 dBZ returns. Using the Echo Top Product as an aid for placing the cross section line may be helpful.
6. Monitor the formation/dissipation of precipitation events.
Discussion: This would be helpful with high based convection or with convection which initially develops aloft.

Composite Reflectivity (CR)

Limitations

1. Low level reflectivity signatures are obscured.
Discussion: Because the algorithm uses the maximum reflectivity for each grid box from any elevation angle, many characteristic signatures will be masked. The CR product will show features, such as hook echos, at the low slice with the echo overhang attained from the higher slice. DO NOT use the CR product by itself to diagnose the presence of hook echoes, BWERs, WERs, Inflow Notches, boundaries, etc.
2. Height of reflectivity is unknown.
Discussion: One grid box may be from 0.5° , while the grid box next to it may be from 10.0° .
3. Echo aloft can't be discriminated from precipitation reaching the surface.
Discussion: What looks like precipitation, may actually be cloud layers at 15kft! Be especially careful when using the CR product to infer the location of snow or very light rain, as much of it may in fact be aloft.
4. Non-precipitation echoes may contaminate product.
Discussion: If Non-precipitation echoes or ground clutter are present in the Base Reflectivity data they will make their way into the CR product.

Strengths and Applications

1. Reveals highest reflectivity in all echoes.
Discussion: This is a quick way to check which storms have the highest reflectivity present.
2. Determine storm structure features & intensity trends in storms. (When compared with base products).
Discussion: While a CR product BY ITSELF can not be used to determine storm structure, it can be very useful when used in conjunction with other products. By displaying a 0.5° reflectivity product on one screen and a CR product on the other, you can (with cursors linked) assess the location and extent of the echo overhang.
3. Generate cross sections through maximum reflectivity knowing the inflow side of storm.
Discussion: Once you see a core of 65 dBZ, you probably want to know if it's one pixel, shallow, or has great vertical extent. You can use the CR product to help place the line for the RCS and determine these attributes.
4. Combined Attribute Table is available.
Discussion: On no other product can you display this table. It is a quick way to scan output from several algorithms without having to check through several products.

Layer Composite Reflectivity Maximum (LRM)

Limitations

1. Mid & Low layer products will use few elevation angles at long distances.
Discussion: At long ranges where the 0.5° slice is at a considerable altitude, there may be only 1 or 2 slices used to compute the max value. At closer ranges, there will be data from several slices.
2. Mid and High level products are ineffective at close range due to the cone of silence.
Discussion: There will be a hole around the radar location where the cone of silence precludes data from being used for especially the mid and high level product. That does NOT mean echo does not exist over the radar site!
3. Low layer product susceptible to non-precipitation echoes.
Discussion: Generally speaking, the low layer is the one susceptible to ground clutter returns (anything that makes it into base reflectivity data, will make it into the LRM products). The amount of contamination will depend on the altitude used for the base of the LRM product. Often, the mid and high layer products will not have this problems except on rare occasions when the returns have significant vertical extent.

Strengths and Applications

1. LRM products can be used to estimate the height of higher reflectivities.
Discussion: Monitoring the LRM products may assist forecasters in getting a jump on the height of higher reflectivity cores. For instance, raising the lower layer boundary to the melting level may provide the forecaster valuable information on the height and intensity of developing pulse-type

storms by using the LRM-Low product.

2. Comparison of Base Reflectivity and Mid or High Layer Composite Reflectivity Maximum product may aid in determining a storm's intensity trend.

Discussion: If the lowest slice Base Reflectivity and the corresponding Mid layer LRM shows significant echoes in the same vicinity, you could infer that the storm is still dominated by updraft with almost all of the echo aloft. In pulse type thunderstorms, this may be the only lead time you get for warning purposes.

3. Use of the low or mid level product can help differentiate ground clutter from precipitation echoes.

Discussion: Clutter which is evident on the lower slices of a Base Reflectivity, will most of the time completely disappear on the LRM-Mid Layer product. Use of the LRM-Low Layer product for this purpose would require raising the height definition to above the ground clutter.

LRM - Anomalous Propagation Removed (APR)

Limitations

1. The product can be misleading if traditional clutter filtering is not applied or is ineffective.

Discussion: Residual clutter can still contaminate the product. Unsuspecting users may assume all data displayed on the product is precipitation echo since the product name indicates AP has been removed. The algorithm assumes all low level data within 45km of the RDA is clutter.

This may result in valid data being removed in the vicinity of the RDA. Current adaptable parameter settings may not be optimal. Further testing may be needed to enhance algorithm performance.

Strengths and Applications

1. The algorithm attempts to distinguish weather targets from clutter targets.

Discussion: Especially when traditional clutter filtering is invoked and effective, the product gives a good depiction of weather targets.

Echo Tops (ET)

Limitations

1. A circular stair-stepped appearance will often be evident due to use of beam centerline.

Discussion: Because of the sampling technique used to interrogate the atmosphere (that of VCPs), a feature sampled at a particular range will only be displayed at the altitude of one particular elevation angle. While the actual echo probably increases and decreases gradually in altitude with range, each grid point will be assigned only a beam center point altitude. This means that two adjacent bins, that may be sampled by 2 different elevation angles, will be portrayed at very different altitudes.

2. No upward extrapolation from the last elevation angle where precipitation was detected.

Discussion: Echos that actually end somewhere between elevation angles will be affected. They will be underestimated as the top is truncated to the last angle echo was detected. As with many volume products, this will be more of a problem in VCP 21 closer to the RDA since there are more gaps.

3. Side lobes may result in overestimated top.

Discussion: This may happen on rare occasions. Investigating the Base Reflectivity or the RCS product may help.

4. Tops will be underestimated close to the radar due to the cone of silence.

Discussion: A time lapse of the ET product showing a storm approaching the radar will indicate the tops decreasing as they approach the cone of silence, and then increasing as they move away.

5. Difficult to locate the highest echo top in a storm due to lack of upward vertical extrapolation, and heights are displayed in 5000 ft increments.

Discussion: It is therefore prudent to keep in mind that these are estimates of the Echo Top.

Strengths and Applications

1. Quick estimation of the most intense convection; higher echo tops.
Discussion: When time management is critical, this product may help you know which storms to investigate first (similar to how the VIL assists in this endeavor).
2. Assist in differentiating non-precipitation echoes from real storms.
Discussion: Most of the time AP has very little vertical extent.
3. Aids in identification of storm structure features such as tilt, updraft flank, max top over strong low level reflectivity gradient, etc.
Discussion: Another good User Function to have is a 4panel using 3 elevations of Base Reflectivity and the ET product in the fourth quadrant. You can still use proven techniques (such as the Lemon Technique) to help assess storm structure and severity.
4. May detect mid-level echoes before low-level echoes are detected.
Discussion: This is especially beneficial when echo cores primarily develop aloft. In pulse thunderstorm situations, there may be only one or two volume scans where the core remains aloft before descending to the surface. This product may enable you to get positive lead time on a warning for such a storm.

III. Velocity Derived Products

Storm-Relative Mean Radial Velocity Map (SRM)

Limitations

1. Storm-relative flow will be inaccurate if the storm motion subtracted isn't representative of the storm being investigated.
Discussion: There are a couple of instances in which you should keep this in mind. The first is when the SCIT algorithm is not tracking anything well. Recall limitations in the SCIT algorithm which can lead to erroneous storm motions. If this motion is significantly in error, actual features may be totally obscured in the SRM product. The second, is when the SCIT algorithm is actually doing very well but the storms are moving in different directions. When the average of these storms is taken, the resultant motion may be non-representative of any one storm. In these cases, the user should override the default motion and input one of their own.
2. More difficult to determine actual ground-relative winds.
Discussion: If you want to estimate the impact of the gust front as it slams into your office, you don't want to subtract out that storm motion.
3. Average storm-relative motion likely will vary from volume scan to volume scan.
Discussion: SCIT computes the average storm motion each volume scan. Therefore when strong rotation on one scan appears not as strong on the next scan, it may really be due to a change in the average storm motion used.
4. Data levels differ from Base Velocity product.
Discussion: Remember the Base Velocity data levels can be changed to anything. The SRM data levels are fixed at +/- 50kts. This may also lead to very different calculations of VR/SHEAR from a Base Velocity to a SRM product. Which one is more accurate? It depends! The smaller the change from one data level to another, the smaller the possible error in VR calculation (since VR/SHEAR uses the mid-range value from the selected data level to the next highest data level).

Strengths and Applications

1. Used to investigate the 3-D velocity structure of a storm when used in a 4 panel.
Discussion: Remember to have *at least* 4 elevations of SRM (same elevations as were chosen for Base Reflectivity) on your RPS List. You will want to sample the lowest, middle and top portions of the storm in your 4-panel presentation. Keep in mind how range and VCP issues may minimize or optimize your ability to sample the storm at these locations.
2. Most useful with faster moving storms (> 10 kts).
Discussion: If you can't identify a rotational signature, you may not even consider warning for it..

Subtracting out the storm motion is like viewing the storm as if it were standing still, thereby allowing the rotation signature to stand out.

3. Operator may input storm motion at AWIPS.

Discussion: If you don't like the default, input your own motion and make a one time request.

4. Input a "ZERO" storm motion will output max velocities for 0.54 **resolution velocity product**.

Discussion: This is one way to get the max value for every 4 gates, unlike Base Velocity products which show the 1st of every 4. Especially helpful in light wind flow situations. Note that if you put the SRM on your RPS List and no storms are identified, you will essentially get a Base Velocity product showing the max of the 4 gates since no storm motion will be subtracted.

Storm-Relative Mean Radial Velocity Region (SRR)

Limitations

1. Storm-relative flow will be inaccurate if storm motion used isn't representative of storm being investigated.

Discussion: The same considerations that applied to SRM also apply to SRR.

2. Difficult to determine ground-relative winds.

Discussion: As with the SRM, you don't want to use the SRR to determine ground relative winds. A Base Velocity product would be more appropriate.

3. Limited viewing area .

Discussion: The limited viewing area makes it inappropriate to put this product on the RPS List (in most instances).

4. Data levels differ from Base Velocity product.

Discussion: The data levels on the SRR or the same as the SRM, +/- 50kts, not adaptable.

Strengths and Applications

1. There is better resolution and less chance for storm-relative error on the SRR than on the SRM product.

Discussion: The resolution of the SRR is .27 nm and uses only one storm motion as default, versus .54 nm resolution and the average of all storms with SRM.

2. Aids in displaying: shear and rotation in storms, and storm top divergence.

Discussion: The value of the SRR product (like the SRM product) is to isolate shears and rotation on fast-moving (especially) storms.

3. Operator may input storm motion at AWIPS.

Discussion: As with the SRM, you may override the default if you choose with a motion of your own. On especially significant storms, you may choose to do this at several elevation angles for the most accurate representation.

4. Displayed max inbound/outbound velocities are valid within a small area.

Discussion: This can be especially helpful if the velocities in the signature of interest exceed 50kts. Since the max values only apply to the window, you can better ascertain the actual velocities.

5. Can obtain a .27 nm resolution storm relative velocity product anywhere within 124 nm of the radar.

Discussion: With Base Velocity, the limit of .27nm resolution data was 62nm. You can now get this resolution out to 124nm.

Velocity Cross Section (VCS)

Limitations

1. Doppler velocities are relative to the RDA.

Discussion: As stressed in Velocity Interpretation, you must always know where the phenomenon is in relation to the RDA. It is recommended that you display the Current Cross Section Overlay on one screen (left) and the corresponding cross section on the opposite screen. Attempt to interpret a velocity cross section without knowing where the RDA is relative to it, is impossible!

2. Height vs range exaggeration.

Discussion: With the grid used, the height can be up to 70Kft with the range up to 124nm. This is

the same limitation observed in the RCS product that makes features look skinny and taller than they look out your window.

3. Interpolation may enlarge or miss features.

Discussion: Just as with the RCS product, gaps in the VCP will result in interpolation which may smooth through or enlarge a particular feature.

4. Storm-relative cross section is NOT available.

Discussion: This may make it difficult to interpret signatures in especially fast moving storms.

5. Storm top divergence estimates are limited due to radar viewing angle and data thresholds.

Discussion: Difficult to determine hail larger than golf ball size using NSSL criteria unless both maxima listed on the top of the grid are close to the storm summit. As always, the ability to see features with the cross section products is highly dependent upon placement of the cross section.

Strengths and Applications

1. Aid in determining storm structure features.

Discussion: These features include:

- a. Inferring location of **updraft/downdraft interface** - as seen on a VCS taken down the radial.

- b. Strength of **storm top divergence** - When scanning down radial, we are looking for convergence at low levels, updraft/downdraft interface, and finally divergence at storm summit.

- c. **Depth of mesocyclones** - For this you want a VCS perpendicular to the radial through the mesocyclone.

2. Has proven very valuable for kinematic insights in a research setting.

Discussion: You may have figured it out by now, but Velocity Cross Sections take some practice at interpreting. That (plus the limitations listed above) will probably limit their use during real time. They are however extremely useful for gaining insight to the kinematic workings of the thunderstorm in a research or playback setting.

Velocity Azimuth Display (VAD)

Limitations

1. Needs sufficient data points.

Discussion: Clear, cold, dry air often lacks scatterers. No sine wave will be plotted unless there are at least 25 data points.

2. May be unreliable in disturbed environments.

Discussion: The algorithm assumes horizontal uniformity of the wind field. Imagine a cold front lying across the RDA. You look to the North, the winds are blowing toward the radar. You look toward the South ahead of the front, winds are also blowing toward the radar. The algorithm will have a hard time finding an "average" wind across the area under these circumstances! The wind estimate it gives you (if indeed it gives you one at all) will NOT be very useful.

3. Available for preestablished altitudes only.

Discussion: The altitudes are set at the ORPG HCl. If you want to see winds at any other altitudes, you must change them there (URC level of change authority).

4. Large flocks of migrating birds may produce anomalous wind data.

Discussion: The averaging of the motion of birds in conjunction with the motion of the wind, can lead to erroneous wind data. Birds can cause the speed to be off by several knots and the direction to be off by several degrees. Typical symptoms include an "explosion" of reflectivity returns in a "butterfly" pattern centered on the RDA just after sunset.

Strengths and Applications

1. Winds available in clear air or precipitation mode.

Discussion: Generally speaking, the wind estimates will be slightly better in clear air mode since the radar antenna rotation is slower. This may on some occasions mean you will get winds through a deeper layer as well.

2. Does not require 360 degrees of data.

Discussion: The algorithm only requires 25 data points (that's a sample from 25 degrees of azimuth) and they don't have to be contiguous. The "Beginning" and "Ending" azimuth range is set at the ORPG HCI and is under URC level of change authority.

3. Check missing or suspicious wind data.

Discussion: This is probably the primary reason many operators choose to look at the VAD. When you see "ND" plotted on the VAD Wind Profile, you can go the VAD at that altitude and see what happened.

4. Update Environmental Winds Table.

Discussion: The VAD winds are fed into the Environmental Winds Table for use in the velocity dealiasing algorithm. This helps minimize erroneous winds due to dealiasing failures.

5. VAD winds may be included on the Radar Coded Message (RCM).

VAD Wind Profile (VWP)

Limitations

1. Measurable returns needed - for each altitude, at least 25 data points are required on the VAD for a sine wave to be plotted. If one is not plotted, the wind will not be calculated at that altitude.

Discussion: In what instance might you think scatterers would be few and far between? Generally, the dryer and more pristine the atmosphere, the fewer the number of scatterers. This would likely occur with the intrusion of a clear, dry arctic airmass. In addition very high altitudes which are free of clouds will seldom have enough scatterers to produce reflectivity return.

2. Winds are not encoded if RMS error or symmetry thresholds are exceeded.

Discussion: If the points don't fit the sine curve well enough (RMS exceeds 9.7 kts), or if the winds are too convergent or divergent across the RDA (symmetry exceeds 13.6 kts), then "ND" will be plotted at that altitude of the VWP.

3. Generally only representative of winds within 20 nm of the RDA.

Discussion: This is a wind estimate, averaged around 360° of the RDA. It is attempted to be taken at the same range (default slant range) at all elevations. While this gives a good estimate of a "profile" of the winds at the surface and aloft near the RDA, it tells you nothing about winds at much further ranges.

4. Difficult to read wind barbs when north wind barbs and south wind barbs are on successive altitudes.

Discussion: When winds are due north or due south at adjacent altitudes, the barbs may tend to overwrite each other. Use of the Filter or Blink Functions may help.

5. Birds can produce anomalous wind patterns.

Discussion: The usual scenario is an "explosion" of reflectivity coverage and strength as night migrating birds take off. Experts claim that a single Sea Gull can be detected at a range of 460 km. If it is critical to determine the true upper winds, the site should take a supplemental balloon sounding.

Strengths and Applications

1. The VAD Wind Profile (VWP) may be of assistance in forecast and warning operations.

Discussion: **Severe Weather** operations may benefit as backing or veering of the winds with time display changes in the environment.

Aviation operations will be assisted by evidence of wind shear. Low level wind shear may be more visible on VWP than Profilers. **Hydrology** and **Forecasting** may benefit from indications of the change in the depth of cold air with time, etc. In addition, since sufficient scatterers are often more prevalent in and near clouds, the VWP may be used in estimating cloud tops and bases, and the change of those bases and tops as the cloud layer approaches or recedes.

2. The VWP can be used to create/adjust hodographs.

Discussion: Remember to use the VWP of the radar whose environment most closely resembles that of the storms being sampled.

3. Future development may include combining the Storm Tracking Algorithm and VAD Wind Profile to output helicity.

Discussion: The integration of data sets into one workstation will allow for this and other

applications to be developed.

Mesocyclone(M)

Limitations

1. Time continuity is not employed.
Discussion: The algorithm does not wait for 2 volume scans. If it is identified on one volume scan, it is classified as a Mesocyclone. This means that transient shears can be identified on one volume scan, and then lost on the next. Recall that for an “operator” identified mesocyclone, you would most of the time want some kind of time continuity to establish validity.
2. Does not need 10,000 ft deep circulation.
Discussion: The algorithm only requires 2 vertically linked elevation angles. If the feature is very close to the radar, the vertical depth provided by two adjacent slices may be only 1Kft. Shears along boundaries close to the RDA will often trigger detections because of this.
3. The algorithm only detects cyclonic rotations.
Discussion: Because the algorithm looks for “increasing” velocity values when defining pattern vectors, an anticyclonic circulation (where velocity values decrease azimuthally) would not pass the test.
4. Identification is influenced by aspect ratio.
Discussion: Since the beam gets broader with range, large features will be harder to resolve and small features may be missed entirely. You should always consider the effects of sampling on the algorithm’s ability to detect features and use a closer radar if possible.
5. Don't know which elevation angle to examine shear.
Discussion: The Attribute Table and Mesocyclone Alphanumeric Product only give height of the feature. Can you say right off what elevation angle you need to look at in order to validate a particular height? You would likely have to refer to a range/height diagram to see what slice you need to look at.
6. Range thresholds may discard or improperly classify mesocyclones.
Discussion: Because of the MAX HGT MESO value, NO mesocyclones will be identified beyond about 110nm. This is because the algorithm will ignore anything above 26Kft. Beyond 110nm, the 1.5 degree slice is at this altitude. It will therefore be ignored. As a result, the best you can do beyond this range is Uncorrelated Shear. In addition, within about 5nm of the RDA, the velocity information will also be ignored.
7. Improper dealiasing may generate false mesocyclones.
Discussion: You will need to examine velocity data to see what the input into the algorithm was.
8. Algorithm default values adapted for “classic” supercells.
Discussion: Modifications to adaptable parameters (pattern vectors, for instance) will help to customize this algorithm for your area or for a particular environment.

Strengths and Applications

1. Identify mesocyclones.
Discussion: The algorithm does a good job in analyzing all velocity information at every slice in the volume scan to give you a good first look at possible significant circulation. The operator must then incorporate reflectivity, SRM, as well as other sources of input to verify the existence of mesocyclones.
2. A mid-level mesocyclone that lowers toward the surface may indicate a tornado is developing.
Discussion: A mesocyclone that develops in the mid levels, and then begins to descend and strengthen with time can be indicative of imminent tornadic activity. You can monitor the base of the mesocyclone in the attribute table (or in the alphanumeric product) to help diagnose this.

Tornadic Vortex Signature (TVS)

Limitations

1. Adaptable parameters need more research.
Discussion: Parameters which work well in one type of meteorological setting may not be as

effective in other situations. More research on the results of various adaptable parameter settings is also needed.

2. Use may require a change in operational philosophy.

If forecasters are used to a low false alarm rate with TVS detections, they will have to learn the best way to incorporate a higher FAR in exchange for a higher probability of detection. There will be a learning curve associated with this change.

3. Little guidance is available on the use of algorithm identified ETVSs.

Minimal research has been done to date on the application of algorithm identified ETVSs and their association with tornadoes. Forecasters should use ETVS output with caution until they develop a better understanding of its utility.

Strengths and Applications

1. Algorithm searches for gate-to-gate shears.

Discussion: The definition of an operator defined TVS is based on gate-to-gate shear associated with tornadic circulations. The algorithm attempts to follow this definition.

2. The algorithm uses multiple velocity thresholds to isolate high shear regions.

Discussion: In areas of broad shear, such as along a squall line, the higher velocity thresholds help to identify small scale circulations within high-shear zones, such as what you would find along the comma-head in a bow echo.

3. More information is passed along about the shear type and strength.

Information depicted about each feature includes whether or not it is a TVS or an ETVS as well as the relative strength and vertical depth of the feature. This information can be operationally significant when attempting to rank and sort through identified features.

4. Adaptable parameters allow for fine tuning of algorithm output.

Through a number of parameter sets as well as individual adaptable parameters, operators can fine tune the output for their location and environment, as well as operator preference. As a result, it is more likely that operationally significant shear regions will be detected.

IV. Precipitation Algorithms and Products

Precipitation Processing Subsystem

Limitations

1. Algorithms do not account for:
 - a) below beam effects (wind, evaporation, or coalescence)
 - b) non-uniform z/r relationships within the radar coverage area
2. Algorithms do not always account for:
 - a) bright band contamination
 - b) hail contamination
 - c) inaccuracies due to radar outages

Strengths and Applications

1. They are the only source of real time high resolution rainfall accumulations.
2. Algorithms use significant quality controls designed to produce better products by:
 - a) minimizing overestimation from ground clutter caused by anomalous propagation
 - b) eliminating reflectivity outliers and spurious noise
 - c) reducing the effects of beam blockage

One Hour Precipitation (OHP)

Limitations

1. After extended outages, the first product will not be generated for 54 minutes.
2. For some events, viewing interval is too short.

Strengths and Applications

1. Assess rainfall accumulations for flash flood watches, warnings, and statements
2. Nowcasts and special weather statements
3. Time lapse can provide storm movement
4. Other water management applications

Three Hour Precipitation (THP)**Limitations**

1. The product updated only once per hour.

Strengths and Applications

1. The THP provides a longer viewing interval.
2. For very long duration events, it can be used with Storm Total Product for analysis.
3. The three-hour interval corresponds to timing of flash flood guidance values.

Storm Total Precipitation (STP)**Limitations**

1. At some sites, the system can stay in category 1 or 2 for extended periods of time (can not manually reset to zero).
2. The product could include missing data without the knowledge of the operator.

Strengths and Applications

1. The product can be used to monitor total precipitation accumulation.
2. It provides a good estimate of ground saturation and/or total basin runoff.
3. The product is very useful for post storm analysis.
4. When used in a time lapse, it is useful for tracking the motion of storms.

User Selectable Precipitation (USP)**Limitations**

1. USP accumulations are updated only at the top of the hour.
2. The product may contain missing data. At least two thirds of the specified hourly accumulations must be available for product generation.
3. Since the USP is a customized product, only 10 can be generated per volume scan.

Strengths and Applications

1. The product provides a flexible time interval to meet varying weather situations.
2. In addition to the 24 hour default USP, any others generated for associated users are available as a one-time request to non-associated users.

Hybrid Scan Reflectivity(HSR)**Limitations**

1. The tilt test may eliminate valid returns at 0.5°.
2. Bi-Scan Maximization may increase negative impact of bright band contamination.

Strengths and Applications

1. View reflectivity used for precipitation products.
2. Assess the accuracy of the precipitation products.
3. Quickly search for inconsistencies in the data.
4. Assist operator in discriminating between precipitation returns and ground returns due to anomalous propagation.

Digital Hybrid Scan Reflectivity(DHR)

Limitations

1. Large product size

Strengths and Applications

1. High resolution (256 data levels) allows for innovative color tables.
2. High accuracy (0.5 dBZ)
3. Used in the generation of external products.
 - Flash flood Monitoring and Prediction (FFMP)
 - Jendrowski Scripts (multiple Z/R AWIPS Application)
 - Areal Mean Basis Estimated Rainfall (AMBER)

